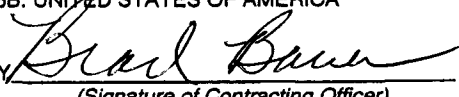


AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT				1. CONTRACT ID CODE	PAGE 1 OF 135 PAGES
2. AMENDMENT/MODIFICATION NO. M010	3. EFFECTIVE DATE See Block 16C	4. REQUISITION/PURCHASE REQ. NO. 07-02ID13729.004	5. PROJECT NO. <i>(If applicable)</i>		
6. ISSUED BY U.S. Department of Energy Idaho Operations Office Procurement Services Division 850 Energy Drive Idaho Falls, ID 83401-1563		7. ADMINISTERED BY <i>(If other than Item 6)</i> Brad Bauer Tel: (208) 526-0090 Fax: (208) 526-5548 E-mail: bauerbg@id.doe.gov		CODE	
8. NAME AND ADDRESS OF CONTRACTOR <i>(No., street, county, state, ZIP Code)</i> Foster Wheeler Environmental Corporation 3200 George Washington Way, Suite G Richland, WA 99352			9A. AMENDMENT OF SOLICITATION NO.		
			9B. DATED <i>(SEE ITEM 11)</i>		
			10A. MODIFICATION OF CONTRACT/ORDER NO. DE-AC07-00ID13729		
			10B. DATED <i>(SEE ITEM 13)</i> May 19, 2000		
CODE		FACILITY CODE			
11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS					
<input type="checkbox"/> The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers <input type="checkbox"/> is extended, <input type="checkbox"/> is not extended. Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation as amended, by one of the following methods: (a) By completing Items 8 and 15, and returning ____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.					
12. ACCOUNTING AND APPROPRIATION DATA <i>(If required)</i>					
13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS; IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.					
X	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO <i>(Specify authority):</i> FAR 52.243-1 CHANGES--FIXED-PRICE AUG 1987 ALTERNATE I THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.				
	B. THE ABOVE-NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES <i>(Such as changes in paying office, appropriation date, etc.)</i> SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).				
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:				
	D. OTHER <i>(Specify type of modification and authority):</i>				
E. IMPORTANT: Contractor <input checked="" type="checkbox"/> is not, <input type="checkbox"/> is required to sign this document and return ____ copies to the issuing office.					
14. DESCRIPTION OF AMENDMENT/MODIFICATION <i>(Organized by UCF section headings, including solicitation/contract subject matter where feasible)</i> This is a unilateral change order issued pursuant to Section I, FAR 52.243-1 CHANGES--FIXED-PRICE of the contract, and the direction provided in letter INTEC-PSF-02-023, dated May 10, 2002. The contractor shall immediately proceed under the changes to Section C-A, C-A-A, and Section J, Attachment J-L contained on the following pages. The contractor shall submit its proposal for an equitable adjustment as a result of these changes within 30 days from the date in block 16C.					
Except as provided herein, all terms and conditions of the document referenced in Items 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.					
15A. NAME AND TITLE OF SIGNER <i>(Type or print)</i>			16A. NAME AND TITLE OF CONTRACTING OFFICER <i>(Type or print)</i> Brad Bauer Contracting Officer		
15B. CONTRACTOR/OFFEROR BY <u> N/A </u> <i>(Signature of person authorized to sign)</i>	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA BY <u></u> <i>(Signature of Contracting Officer)</i>		16C. DATE SIGNED <u>7/26/02</u>	

**U.S. DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE**

July 2002

GENERAL SPECIFICATIONS

For

**SPENT NUCLEAR FUEL DRY
STORAGE PROJECT**

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GENERAL SPECIFICATIONS

1.0 SCOPE

1.1 Background

The Government is committed to packaging Spent Nuclear Fuel (SNF) for interim dry storage and future shipment from the Idaho National Engineering and Environmental Laboratory (INEEL). The fuel handling and interim storage shall comply with the license conditions pursuant to Nuclear Regulatory Commission (NRC) requirements for dry storage and shipping in accordance with Title 10, Parts 20, 21, 71 & 72, and associated referenced regulations of the Code of Federal Regulations (CFR), effective at time of award.

The Contractor shall:

- Design, license, permit, construct and operate a facility to re-package the SNF for dry storage to be known as the Dry Transfer Facility (DTF)
- Provide packaging of SNF in standardized canisters
- Place the SNF into the storage containers
- Design, license, permit, construct and operate an independent spent fuel storage installation (ISFSI) for the containers
- Monitor and operate its facility in accordance with permitting and licensing requirements
- Transport the SNF storage containers from the packaging facility to the ISFSI
- Provide a conceptual design for a transportation system for unrestricted shipment of the packaged SNF that is fully compatible with the storage and handling system

Ultimately, the packages will be transferred off site, but this operation is not included in the scope of this project.

Spent fuel transfer and placement in dry storage shall be performed at the Idaho Nuclear Technology & Engineering Center (INTEC). The INTEC is located within the INEEL, approximately 50 miles west of Idaho Falls, Idaho.

1.2 Included Work

The Contractor shall provide fuel handling and dry storage capabilities by designing, licensing, permitting, constructing, and operating a Dry Transfer Facility (DTF) and an Independent Spent Fuel Storage Installation (ISFSI) at the INTEC. The submittals and deliverables associated with this work are listed in the Contract Submittals and Deliverables Schedule. The DTF and the ISFSI shall comply with the Nuclear Regulatory Commission (NRC) requirements for dry storage and shipping in accordance with Title 10, Parts 20, 21, 71 & 72, and associated referenced regulations of the Code of Federal Regulations. All applicable federal, state, and local permits, and licenses that are required for the construction and operation of these facilities are the responsibility of the Contractor. All activities defined in this General Specification document are the responsibility of the Contractor unless an activity is explicitly designated otherwise.

The DTF shall have capabilities for the following:

- receipt of shipping casks (currently in service within the DOE complex)
- fuel unloading and handling
- removal of fuels from existing storage packages
- visual inspection and inventory of fuels
- treatment of fuels to meet NRC licensing requirements
- re-packaging of fuels into specified canisters
- placement of repackaged fuel into dry storage system units
- transfer of storage units to the ISFSI.

The ISFSI shall provide easily retrievable storage capability for the designated SNF types. The facilities and storage system shall be designed and constructed to be consistent with the appropriate NRC standard review plans and NUREG documents.

The Contractor shall provide NRC-licensed, dry storage to meet specific fuel requirements (See Attachment A). The fuel shall be packaged for dry storage so that it satisfies the requirements defined in this specification, 10 CFR Part 72, and is readily transported between the DTF and the ISFSI. In addition, the Contractor shall provide a conceptual design for a rail-based transportation system for unrestricted shipment of the packaged SNF that is fully compatible with the storage and handling system under 10 CFR Part 71. This transportation system may be provided in a single, dual-purpose system, or the transportation system may be separate from the storage system. The transportation system is not to be fabricated, or licensed under the scope of this procurement. The Contractor shall also design and fabricate, or procure standard canisters compatible with the

specifications provided by DOE for the packaging, storage, and eventual transportation of the SNF.

The Contractor shall provide all design, analysis, shop and field labor, materials, equipment, supplies, and procedures; and perform all work necessary to construct, test and operate the DTF and ISFSI, and shall provide a conceptual design for an offsite transportation system for future use by DOE. The Contractor shall procure all necessary permits and abide by all applicable laws, regulations and ordinances of the United States and of the state, territory, and political subdivision in which the work is performed. The Contractor shall prepare the NRC license application, obtain an NRC license, and remain as the NRC licensee of the DTF and ISFSI until transfer to DOE-ID at the conclusion of the Contract. The Contractor shall operate the DTF and place the fuel packages in the ISFSI. The Contractor shall be the facility owner and operator, unless otherwise transferred in accordance with the provisions of Section H of this contract.

The SNF to be packaged and stored is Peach Bottom Cores 1 and 2, Shippingport LWBR, and TRIGA. The fuel handling requirements, current fuel packaging descriptions, and fuel data are included in Section 4.3.6 of this specification, Attachment C-A-A to this specification, and Section J, Attachment L. These data shall be used to develop safety analysis input and design inputs for safety systems. The Contractor is responsible for performing all necessary evaluation and analyses of the data contained in the reports provided to support design and licensing.

1.3 Utility Tie-ins and Interfaces

DOE can provide available utility connections at the established boundary of the DTF/ISFSI site upon request. DOE will provide these utilities to the west boundary of the project site. A list of the available utilities is provided in Section J, Attachment J-C, Site Service Information of the Contract. The Contractor shall complete all utility tie-ins at this boundary, except for the communications and alarms and security system connections, which are specifically addressed in Sections 4 and 5 of this specification.

2.0 QUALITY ASSURANCE AND QUALIFICATIONS REQUIREMENTS

The Contractor shall have and implement a Quality Assurance Program and Implementing Procedures that are accepted by the Nuclear Regulatory Commission (NRC) for activities associated with spent nuclear fuel transportation casks, fuel handling and fuel storage casks, and licensed storage and packaging facilities. The QA Program shall at least meet the minimum requirements of 10 CFR 20 Standards for Protection Against Radiation, 10 CFR 21 Reporting of Defects and Noncompliance, 10 CFR 71 Packaging and Transportation of Radioactive Materials, Subpart "H", 10 CFR 72 Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High Level Radioactive Waste, Subpart "G", and associated referenced regulations. A Quality Assurance program that complies with ASME NQA-1 including all supplements and addenda, enhanced as necessary to provide NRC approval, satisfies this requirement.

3.0 APPLICABLE CODES, STANDARDS, AND REFERENCES

Compliance with applicable codes and standards used for the design, construction, testing, and operation of the entire system shall be delineated as part of the NRC license application.

The Contractor shall prepare a Requirements Document that describes all applicable codes and standards that will be used as the design, NRC licensing, permitting, and operating basis for the facilities. This document shall be submitted to DOE and shall be revised as necessary during development of the safety analysis report and design to keep it consistent with the permitting and licensing basis. The Contractor shall include the identification of applicable regulatory standards and manuals for the entire project in this document, including items not regulated by the NRC. The Requirements Document shall be the technical basis for development of the NRC License Application. Except for items not covered by 10 CFR Parts 20, 21, 71 and 72, and associated referenced regulations, the Requirements Document shall be superseded by the NRC approved licensing conditions and all design, review, analysis, construction, testing, start-up, and operations shall comply with the license and permit conditions.

4.0 DESIGN

4.1. Design Development

The Contractor shall develop and document all designs necessary to license, permit, construct and operate the required facilities and systems in accordance with the following requirements.

4.1.1 Performance and Design

The Contractor shall use best management practices at all times. The technical and safety requirements outlined in 10 CFR 20, 21, 71 & 72 (and associated referenced regulations), and ANSI/ANS 57.9 are the design, construction, and operating bases for the DTF and ISFSI. As such, the dry fuel storage and transport system(s) shall be based on an existing system(s) with a well-established history of satisfactory (i.e., regulatory compliant) operating experience for dry spent nuclear fuel storage and transport.

4.1.2 Initial Design

The Contractor shall complete the preparation of the facility and storage system designs sufficient for submittal of the license application, and its acceptance for review by the NRC. The design shall include enough necessary detail to adequately describe all safety aspects and conditions of the facilities to meet the specified and approved requirements listed in the Requirements Document (See 3.0 of this Specification). The design shall include, as a minimum, the following items:

- detailed calculation and computer codes

- detailed drawings and descriptions of all major disciplines, systems, and processes
- equipment lists
- Safety Analysis Report
- specifications, and
- draft subcontract documents.

A conceptual design for a rail-based transportation system for unrestricted off-site shipment of the packaged SNF shall be prepared in parallel with preparation of the transfer and storage facility design.

The Contractor agrees to conduct an oral design presentation for DOE at DOE-ID's place of business when the transfer and storage facility design has been completed to approximately the 50% level. The conceptual transportation system design will be presented at this time as well. The design presentation shall demonstrate how the entire design is progressing in order to comply with the Contract requirements.

4.1.3 NRC Licensing

The Contractor shall obtain NRC license(s) for the handling, packaging and storage of the specified SNF in the DTF and ISFSI under 10 CFR Parts 20, 21, 71 and 72, and shall operate the same in accordance with the conditions and commitments of the license. The Contractor shall be the licensee and operator of the DTF and ISFSI. As licensee, the Contractor shall prepare all license applications and documentation in accordance with Parts 71 and 72, and associated referenced regulations as appropriate, perform all supporting calculations, and submit the license applications to the NRC for review and approval. The license shall be for the maximum time period allowed by NRC under the regulations. The Contractor shall use appropriate NRC standard review plans and NUREG guidance in the preparation of the design(s) and license application(s). The license application shall demonstrate that the published standards are applicable to the fuels within the scope of this contract. In the event the acceptance criteria described in the Standard Review Plans (NUREGs 1536 and 1567) are not sufficient for these fuels, the application shall include additional proposed acceptance criteria adequate to satisfy NRC requirements.

[Note: The DOE SNF standard canister shall be designed for use for storage under 10 CFR 72, and unrestricted transportation under 10 CFR 71. The scope of work under the base contract does not, however, include licensing the transportation system.]

During the course of NRC's review of the application, the Contractor shall maintain open and consistent communications with the NRC and shall be

present at all NRC requested review meetings to support the licensing process. The Contractor shall respond to NRC concerns with requisite re-submittals.

The Contractor shall prepare and implement a Management Control Plan, which adequately describes and controls all interfaces between the Contractor, DOE, NRC, and other federal, state, and local agencies. The Management Control Plan shall clearly identify how all interfaces with INEEL utilities and site services will be controlled.

The Contractor shall prepare and submit an Environmental Report with its license application(s) in conformity with NRC regulations. The NRC Environmental Impact Statement produced for the INEEL TMI-2 ISFSI (Docket 72-20) and the DOE Programmatic SNFEIS are available to the Contractor and contain useful reference information. The Contractor shall provide any additional information requested by the NRC.

4.1.4 Permit Applications

During Phase I, the Contractor shall prepare and submit applications for all permits necessary for the start of Phase II and III activities. The Contractor shall sign all permits as owner and operator.

4.1.5 Final Design

Upon receipt of the permits and NRC license(s) for the DTF and the storage system, the Contractor shall revise the design to include all the conditions and commitments of the permits and license(s). The final design shall be used for construction, fabrication, and contracting with subcontractors.

4.2 System Requirements

4.2.1 Natural Phenomena

Structures and their elements shall be designed to withstand natural phenomena at INTEC to meet NRC Regulations. The site conditions document from Chapter 2 of the TMI-2 Safety Analysis Report is offered as general information on site characteristics. This information may be used to develop design-input criteria, as applicable, to develop the Safety Analysis Report for the license application.

4.2.2 Design Life

The ISFSI design life shall provide for the interim storage of the SNF for a minimum of 40 years. The DTF shall be designed for a minimum design life of 40 years. Active components shall be maintainable or replaceable throughout

the design life of the facilities.

4.2.3 Utility Interfaces

During the design phase, the Contractor shall identify all required interfaces such as utilities, roads, and parking areas for the DTF/ISFSI, and submit a utility service request in accordance with Section J, Attachment J-K, Submittal & Deliverables Schedule. See Section J, Attachment J-C, Site Services Information available and/or required services and associated costs. Interface drawings and specifications for existing INTEC systems are provided in Section J, Attachment J-G. DOE will provide these utilities to the west boundary of the project site.

4.3 Functional and Operational Requirements

The functional and operational requirements for the Dry Transfer Facility, Independent Spent Fuel Storage Installation, Transportation System, Fuel Packaging, and supporting equipment are given below. The Contractor is responsible to develop a fuel movement plan as the basis for the facility design and operation that accommodates all the functional and operational requirements of this specification. The fuel movement plan shall include, as a minimum, the activities described in Attachment B, which is a sample fuel movement plan flow sheet.

4.3.1 Dry Transfer Facility

The Contractor shall provide a Dry Transfer Facility (DTF) to meet the following functional requirements:

4.3.1.1 General

The DTF shall be provided with all equipment and capabilities required for the following activities:

- the safe receipt, handling, and unloading of SNF loaded shipping casks
- the safe handling, characterization, conditioning, and repackaging of SNF into storage systems
- the safe transfer of loaded storage systems from the DTF to the ISFSI
- a shipping cask turnaround time of 48-hours

The DTF shall be designed and constructed to accommodate future cost effective, safe, and environmentally sound decontamination and

decommissioning (D&D) to meet NRC regulations.

The DTF shall be designed to prevent the loss of containment and retrievability during all normal and credible off-normal conditions, including the design basis accidents (DBAs).

The DTF shall be designed to allow recovery from credible drop accidents during all phases of cask and fuel handling.

The DTF shall be designed to support all maintenance and equipment replacement that may be required over the design life of the facility.

4.3.1.2 Fuel Receipts/Cask Handling

The DTF shall provide a means for sampling and analyzing gas and/or liquid from cask internal cavities, and for preparing the cavity atmosphere (draining, venting, purging, etc.) to allow the cask to be opened without exceeding the facility radiological control limits (this includes the handling of effluent wastes from the cask cavity). The control limits for the facility shall be established by the Contractor in accordance with NRC regulations, and the facility design parameters.

The Contractor shall design the DTF to receive, handle and unload the Peach Bottom casks specified in Attachment C of this general specification. Additionally, the facility shall be sized to handle a transportation cask envelope (including trunnions and impact limiters) of 128 inches diameter, 308 inches long, and 300,000 pound weight to accommodate potential future operations. (The fully loaded transport vehicle, with cradle, impact limiters, trunnions and loaded cask is estimated at a maximum of 200 tons.)

The DTF shall provide for the decontamination of shipping casks to meet the limits of the NRC radiation safety requirements and/or requirements for over the road shipments prior to release of the cask to the shipper.

The Contractor shall ensure that the radiological control requirements are met for all interfaces between the DOE facilities and the Contractor's NRC regulated facility. The Contractor shall document in the Project Management Plan an approach satisfactory to DOE to ensure the requirements of both facilities are met.

4.3.1.3 Fuel Unloading and Handling, Conditioning, and Repackaging

The DTF shall provide a shielded hot-cell with remote operational capabilities for shipping cask unloading, and SNF handling, conditioning, and repackaging activities.

The cask and SNF handling equipment within the hot-cell shall have remotely changeable components for the handling of fuel types and fuel baskets as specified

in section 4.3.6, and cask and canister shield plugs, and/or hot-cell shield plugs if used.

In-cell equipment shall be designed for recovery from all credible accidents or breakdown conditions.

The DTF shall include features to perform cell and equipment decontamination and to support remote maintenance of contaminated equipment.

The hot-cell shall be capable of being decontaminated and SNF operations suspended during in-cell maintenance.

The DTF shall have the capabilities to characterize, condition and repackage the SNF in accordance with the requirements of sections 4.3.4 through 4.3.6. The facility shall be capable of handling both lengths (10' and 15') and both diameters (18" and 24") of the standard canisters as described in Attachment E to this General Specification.

4.3.1.4 Facility Radiological Control

Optimization methods shall be used to ensure that radiological exposure is maintained As Low As Reasonably Achievable (ALARA) in developing and justifying facility design and physical controls. Radiation protection for occupational workers and interfaces with INTEC shall comply with NRC requirements. The Contractor shall ensure that the radiological control requirements are met for all interfaces between the DOE facilities and the Contractor's NRC regulated facility. The Contractor shall document in the Project Management Plan an approach satisfactory to DOE to ensure the requirements of both facilities are met.

The Contractor shall provide all effluent systems for the DTF/ISFSI as necessary to meet license and permit conditions. An accurate method for measuring the amount of radionuclides in effluents during normal operations, and under accident conditions, shall be provided for these systems. An accurate means of measuring the quantity of the diluting medium, either air or water, shall also be provided. Facility emission limits shall not exceed the limits established for this project in the DOE Programmatic SNFEIS, NRC license and air permits.

4.3.1.5 Shipping Cask Turnaround Time

The total Contractor shipping cask turnaround time (from receipt of a loaded cask into the facility until return of the empty cask) shall be less than 48-hours. Return of the cask shall be at the truck entrance to the DTF.

The DTF shall provide shielded "lag" storage for SNF as required to meet the 48-

hour cask turnaround time. The capacity of the “lag” storage shall accommodate the receipt of SNF in accordance with the Shipping Cask and Fuel Receipt Schedule, Attachment D, without disrupting the DTF operations, and shall be based on the storage system design, shipping cask capacities, and the fuel receipt schedule.

4.3.1.6 Future Off-Site Transportation Operations

A conceptual design shall be prepared for a rail-based transportation system, which provides unrestricted off-site shipment of the packaged SNF. This system shall be compatible with the Contractor’s DTF and ISFSI designs. While the off-site transportation system and operations are not a part of this contract, the facility design shall consider the following capability necessary to support this future activity:

- A staging area for loading off-site transportation casks onto either a truck or a rail car. This area shall be oriented in a manner which accommodates a cost effective and efficient link to the existing rail east of INTEC, which runs in a north-south direction, as well as truck access from the existing INTEC roads.
- Future placement of rails in an off-site transportation staging area (oriented for east-west travel)
- At a minimum, the staging area shall be sized to handle a transportation cask envelope (including trunnions and impact limiters) of 128 inches diameter, 308 inches long, and 300,000-pound weight. (The fully loaded transport vehicle, with cradle, impact limiters, trunnions and loaded cask is estimated at a maximum of 200 tons.)

4.3.1.7 Characterization Operations

The DTF design and operation shall include the capability for performing all necessary fuel characterization in accordance with the NRC license requirements. The DTF must also include unused space for future installation of equipment, such as additional fuel characterization and canning capability, which could be required to support processing of optional fuels. This area must be at least 22 feet by 22 feet of floor space, and must be arranged in such a manner to allow for the full range of motion for the cranes, manipulators and other remote devices and not interfere with other planned activities. The cell ceiling height shall accommodate the cask and fuel requirements defined in Section 4.3.4 and Attachments A and C to this specification. A Motor Control Center (MCC) rated at 277/480-V, 800-A, 3-phase, 4-wire with an 800-A main circuit breaker and ground fault protection shall be installed adjacent to the cell area to supply future power. Eight, two inch diameter wall penetrations must be installed adjacent to the MCC to allow for future routing of power and instrumentation wiring into the cell. A two-inch diameter potable water line must be routed into the cell area and terminated at a

common header. A 1.5-inch plant airline must also be routed into the cell area and terminated at a common header.

4.3.2 Independent Spent Fuel Storage Installation

The Contractor shall provide a NRC-licensed, SNF dry storage system that is compatible with the DTF. The storage system, which has distinct units of a standard size that can be constructed on an individual basis for future expansion, shall be located in an Independent Spent Fuel Storage Installation (ISFSI). The ISFSI shall be designed, constructed, and tested to assure safe storage of the fuel in accordance with the conditions of the NRC license and applicable permits. The ISFSI shall be designed to provide easily retrievable storage capability for the designated SNF types.

The Contractor shall provide all equipment, including a storage system that shall allow the fuel to be safely retrieved from the ISFSI.

The design shall provide weather protection as necessary to allow year-round operations, fuel monitoring, and retrieval capabilities for systems associated with the safe operation of the ISFSI in accordance with NRC regulations and applicable permits. The ISFSI shall incorporate security and physical protection systems to protect the fuel (see 5.1 of this specification). The ISFSI shall be designed and constructed to accommodate cost-effective, safe, and environmentally sound decontamination and decommissioning (D&D).

4.3.3 Transportation System

The Contractor shall provide a conceptual design for a rail-based system for transporting the SNF off site to meet the following requirements:

1. Capable of supporting transport of spent fuel by rail. This system shall be compatible with truck transport (heavy haul).
2. Capable of being licensed and/or permitted in accordance with Department of Transportation (DOT) 49 CFR 173 and 10 CFR 71 for unrestricted transport.
3. May be a separate system from the storage system provided to meet Part 72 dry storage requirements.
4. Must be compatible with the standardized canisters (specifications provided by DOE) to be used for handling, interim storage, transportation and disposal in the national repository for DOE SNF.

Except for tractor, locomotive, and/or rail car, the Contractor design must consider all equipment necessary for transportation operations. This equipment includes items such as cask lifting devices, rubber-tire trailer, and impact limiters. For rail

transport, the system shall be capable of being placed on a standard “heavy load” railcar. Storage space for this equipment shall also be considered in the design.

4.3.4 SNF Packaging

4.3.4.1 Standardized Spent Nuclear Fuel Canisters

Due to the incomplete knowledge of the condition of the existing fuel storage containers and the fuel cladding, the Contractor shall design and fabricate new fuel storage canisters and load all spent fuel into the new canisters. The new canisters shall provide a known containment boundary suitable for NRC licensure for dry storage under 10 CFR Part 72 regulations.

In addition to meeting the dry storage requirements for 10 CFR Part 72, the canisters shall be designed and fabricated to meet the requirements in Attachment E, *Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters—Volume 1 - Design Specification*. The standardized canister is patent-pending, and the design shall remain as property of the United States Government (LMITCO Invention Disclosure LIT-PI-444 “Drop-Resistant Toxic Waste/Spent Nuclear Fuel Canister” Case Number S90,596). Attachment E provides preliminary design specifications for standardized canisters that are 10 feet and 15 feet in length, each with diameters of 18” and 24”. The Peach Bottom fuels shall be placed in the 15-foot-long 18” canisters; the TRIGA fuel shall be placed in the 10-foot-long 18” canisters; the LWBR fuel may be placed in either the 18” or 24” 15-foot-long canisters. Taking into consideration the repository criticality criteria (section 4.3.4.4) and NRC Parts 71 and 72 licensing parameter limits, the canisters shall be loaded to the maximum extent possible.

The final packaged fuel is intended to be repository ready without further processing. Attachment F to this specification includes a list of supplemental requirements based on the current repository criteria, which must be met. Some of the repository requirements are repeated elsewhere in this specification and attachments. The requirements in Attachment F are the responsibility of the Contractor.

A conceptual design for a lifting and handling system has been developed that is compatible with the proposed Standardized DOE SNF canister design. The design for a viable grapple concept is provided in Attachment E. Details of final design features of the grapple will depend on the facility specific lifting and handling criteria. Details of the design presented are purposefully omitted to the extent possible to accentuate that this is a conceptual design. The Contractor shall finalize the design and fabricate the system to NRC requirements.

4.3.4.2 Sealing and Inerting

The standard canister shall be sealed and inerted to meet criteria in Attachment E prior to placement in the ISFSI. The DTF shall provide all necessary equipment to accomplish and verify inerting, drying (to verify moisture content) and sealing of the standard canisters. Provisions for retrieval of individual standard canisters from interim storage within the ISFSI and movement of those canisters within the DTF shall also be provided to allow for future processing of individual standard canisters prior to off-site shipment. All canister components necessary to seal the canisters, such as plugs, shall also be provided.

4.3.4.3 Loading Operations

The loading of the SNF canisters shall be documented in accordance with the Contractor's NRC approved material control and accountability program and 5.2 of this Specification.

The Government, and/or its designated representative, shall have the right to witness and document all aspects of the canister loading operation. The Contractor shall include provisions in the DTF to allow the Government to perform necessary oversight and witness activities during any aspect of the handling or loading operation. The Contractor shall notify DOE sixty (60) days prior to start of canister loading operations so that appropriate notifications can be made.

4.3.4.4 Repository Fissile Loading Limits

The following repository fissile loading limit scoping numbers shall be used to estimate the total number of canisters needed per fuel type. The scoping calculations presented below for the LWBR fuel assumed use of the 18" canister. The Contractor is responsible for estimating the number of canisters required if the 24" canisters are used for LWBR fuel. A report with the preliminary repository loading limits for Peach Bottom fuel in the 18" diameter, 15-foot long canister is included in Section J-L. The calculation of repository fissile loading limits is dependent on the canister dimensions, internals design, geometry, use of poisons, etc. Therefore, the confirmed repository fissile loading limits for the Peach Bottom, Shippingport and TRIGA fuels shall be the responsibility of the Contractor to perform based on the specific design selected.

- Peach Bottom Core 1 and Core 2: Each 15-foot, 18-inch diameter canister can be loaded with up to 13 elements.
- LWBR: 8.27 kg fissile per 15-feet, 18-inch diameter canister.
- TRIGA: 3.75 kg fissile [Beginning Of Life (BOL)] per 10-foot, 18-inch diameter canister.

DOE has only evaluated these three fuel types for the 18" canisters and canister lengths specified here for scoping purposes. The scoping numbers for the LWBR (8.27 kg fissile) and TRIGA (3.75 kg fissile) limits are based on degraded unpoisoned end states for single canisters that may not be most reactive. See Section J-L for the assumptions used in determining the fissile limits for the LWBR and TRIGA fuels.

The Contractor is responsible for all detailed calculations of fuel loading limits and criticality safety (to satisfy both 10 CFR Part 71 and Part 72) for these fuels and the canisters used. The repository methodology defined by the DOE Office of Civilian Radioactive Waste Management shall also be used for any of these additional calculations for repository fissile loading limits. The methodology and guidance are contained in the report titled "Disposal Criticality Analysis Methodology Topical Report," (YMP-TR-004Q), provided in Section J-L. A sample report documenting such an analysis, "Evaluation of Codisposal Viability for Aluminum-Clad DOE-Owned Spent Fuel: Phase II Degraded Codisposal Waste Package Internal Criticality," (BBA000000-01717-5705-00017 Rev 01) is also provided in Section J Attachment J-L document 1-14.

4.3.4.5 External Contamination

In the future, DOE must be able to verify that the 18" and 24" canisters meet certain external contamination limits prior to loading into a transportation cask for off-site shipment. The Contractor shall provide the capabilities, including all necessary equipment, to accomplish this requirement. A demonstration test to prove the capability and that these contamination limits are met shall be performed by the Contractor. Smear tests shall be performed with an absorbent material that has been wiped, using moderate pressure over a representative 300 sq. cm surface area of the container.

4.3.4.6 Labeling

The canisters shall be labeled as specified in 3.2.15 of Attachment E to this Specification. The labeling convention to be used (e.g., bar codes, alphanumeric characters, naming convention, position on the canister, label material) will be provided to the Contractor.

4.3.4.7 Fuel Characterization and Recordkeeping

Records shall be generated which indicate the specific SNF loaded into particular canisters. Photo records of all individual SNF units being loaded into specific canisters shall be provided.

The Contractor shall document the weight of each canister after loading is complete, but prior to sealing, to verify compliance with the canister weight limits listed in Table 3.2 of Attachment E to this General Specification.

Copies of the above documentation shall be provided to DOE in accordance with the deliverables schedule.

4.3.4.8 Canister Drying

The Contractor shall verify that the SNF is dry prior to placing the canister in interim dry storage (see drying criteria below).

4.3.4.9 Criteria

The vendor shall provide the means for subjecting the loaded fuel canister to a vacuum of at least 1 torr. The canister shall be held in vacuum for a period of at least two (2) hours with a pressure rise rate of less than 10 torr per hour.

4.3.5 Fuel and General Handling Equipment

After the DOE or its M&O Contractor delivers SNF to the DTF, the Contractor shall unload the SNF from the transport cask and place it into the Contractor's storage system. All facilities, systems, and equipment shall be designed and operated to meet the NRC nuclear safety requirements.

Provisions shall be made for monitoring the external surfaces of the fuel casks for external radiation levels and radioactive contamination, validation of SNF or canister identification numbers, validation of the inventory, and any other information required by the NRC.

Cranes and lifting fixtures shall be provided, as necessary, to handle casks, canisters, cans, and fuel elements. The lifting fixtures shall interface with the cranes, casks (shipping and transport), and associated equipment such as cask lids, shield plugs and storage canisters. The lifting fixtures shall be designed to facilitate decontamination, nondestructive testing, maintenance, handling, and storage. Cracks or crevices likely to collect contamination shall be eliminated. For a list of the different types of casks to be handled and typical handling hardware, see Attachment C.

The facilities, systems and equipment shall include interlocks, limit switches, redundancy, emergency shutdown and recovery features as necessary to meet the nuclear safety requirements.

Support equipment and procedures required for remote maintenance of failed equipment, off-normal events, and accidents shall be provided for all remote handling equipment.

Handling and process equipment and other support equipment located within the shielded cell shall be designed to function in, or be appropriately shielded from, the high radiation field produced by unshielded fuel units. Safe access to perform necessary testing, inspection, and maintenance shall be provided (e.g., ladders, catwalks, and guardrails).

4.3.6 Fuel Descriptions and Handling Requirements

The Contractor shall receive the specified spent fuel from DOE at the Dry Transfer Facility according to the Shipping Cask and Fuel Receipt Schedule (Attachment D) and place the fuel into the Contractor's NRC approved storage system packages as detailed herein. The Contractor shall prepare and submit a detailed operations schedule indicating receipt of fuels, receipt of storage units, placement of fuels into dry storage, and all other key elements of fuel loading operations. The specific information for each fuel type is contained in Attachment A and Section J Attachment L. The Contractor shall perform fuel loading operations in connection with appropriate material control and accountability requirements (see Sections 5.1 and 5.2 of these specifications). The following provides a summary of the fuel descriptions and handling/packaging requirements.

4.3.6.1. Shippingport LWBR Fuels

The Shippingport LWBR SNF, for the planned campaign within this contract, consists of 2,971 individual rods differentiated into different fuel module assemblies of varying fissile loadings and outer diameters, including one loose rod canister. The assemblies are packaged into 16 uniform canisters, and stored within the underground vaults in dry storage at CPP-749. The canisters variously contain intact modules, partially filled modules, and bare intact rods. The canisters are approximately 158 inches long by 25 ½ inches in diameter. The canisters were dried, sealed, and inerted prior to placement in storage. No inspection of the fuel condition has been made since placement at CPP-749, however, the condition is assumed to be good. Greater fuel description and detail is provided in Attachment A (Fuel and Package Descriptions) of this General Specification

4.3.6.1.1 Handling Requirements

The Contractor shall receive one fuel canister per shipment according to the attached Shipping Cask and Fuel Receipt Schedule (Attachment D). The Contractor shall remove individual rods or fuel module assemblies as received from each canister and place the material in new canisters in accordance with the requirements of Section 4.3.4. The Contractor may use the 24-in diameter standard canister for the placement of entire assemblies where safety and licensing parameters permit. The new standard canisters shall then be placed in the Contractor's licensed storage system to meet the conditions of the license. Prior to placing the fuel rods into the dry storage system, the Contractor shall inspect, inventory, treat, and/or condition the fuel rods, as necessary, to meet this specification and Contractor's NRC licensing conditions for dry storage and transportation. . The DTF and ISFSI facility and equipment design and capability (e.g., for all areas of the facility, such as storage, hot cell, transfer areas, canister closure area, waste management area) shall envelope the source term and mass of the LWBR seed and blanket fuel. Storage tubes originally intended for LWBR fuel shall use 120 watts thermal load as the design basis. The Contractor shall dispose the existing fuel canisters and non-fuel materials from the individual fuel module assemblies in accordance with Section 4.3.7, "Waste Management."

4.3.6.2 Peach Bottom Core 1

The Peach Bottom Core 1 fuel, for the planned campaign within this contract, consists of 813 individual elements (assemblies) differentiated into four types of varying enrichment and materials. The elements are packaged into 814 sealed aluminum storage canisters with stainless steel liners. The canisters are contained within 45 aluminum storage baskets and one stainless steel storage basket, and stored within the underground vaults in dry storage at CPP-749. Failed fuel elements were placed in sealed canisters, inerted, and leak tested. Upon positive leak detection, the canister was packaged into a second aluminum storage canister (salvage canister). The canisters usually contain intact fuel with assembly components, instrumentation, and scrap. One element is disrupted and stored in two separate canisters. Canisters for intact fuel are approximately 153 inches long by 4.48 inches in diameter. The salvage canisters are approximately 158 inches long by 4.73 inches in diameter. Some fuel storage positions have been inspected remotely using television cameras. Water infiltration into the vaults was discovered, as was corrosion of both baskets and canisters. Water may have infiltrated the aluminum canisters, but this has not been confirmed. It is assumed that all baskets and their canisters have been corroded to some extent. During removal of a basket for inspection in 1988, the basket failed. This was due, however, to improper handling and not corrosion. This fuel has since been repackaged and stored in the new second-generation vaults at CPP-749. Greater fuel description and detail is provided in Section C, Attachment C-A (Fuel and Package Descriptions) of this General Specification.

There are an additional 1-1/2 elements stored within the Fuel Examination and Cutting Facility (FECF) located adjacent to the south basin of CPP-603. These elements are in a dry stable condition. They will be sectioned into four pieces, placed into overpack cans, and transferred and stored in the IFSF. From there, they will be shipped to the DTF.

4.3.6.2.1 Handling Requirements

The Contractor shall receive a basket assembly containing up to 18 Core 1 fuel elements (canned) per shipment, according to the attached Shipping Cask and Fuel Receipt Schedule (Attachment D). The fuel assemblies shall be contained in the aluminum fuel cans, staged in the basket assembly. The Contractor shall remove the individual fuel elements from the basket assembly and fuel can(s),

repackage the fuel in accordance with 4.3.4, and place the fuel in the Contractor's storage system to meet the conditions of the NRC license. The Contractor shall inspect, inventory, treat, and/or condition the individual fuel elements, as necessary, to meet this specification and the Contractor's NRC licensing conditions for dry storage and transportation. The Contractor shall dispose the aluminum fuel cans, tools, and non-fuel waste debris in accordance with 4.3.7, "Waste Management."

4.3.6.3 Peach Bottom Core 2

The Peach Bottom Core 2 fuel, for the planned campaign within this contract, consists of 787 individual elements of the same basic type as the Peach Bottom Core 1 fuels – the major difference being the fuel particles are coated with pyrolytic carbon. The elements are packaged dry into 70 unsealed, carbon steel canisters within the dry-side of the CPP-603 fuel storage area, known as the Irradiated Fuel Storage Facility (IFSF). The canisters contain up to 12 elements together with their removed reflectors. The canisters are approximately 129 inches in length by 18 inches in diameter. No internal inspections of the canisters or the fuel have been made since placement within the IFSF. External inspection of the canisters in 1997 showed no corrosion. It is assumed the fuel condition is good, with the exception of broken elements. Greater fuel description and detail is provided in Attachment A (Fuel and Package Descriptions) of this General Specification.

4.3.6.3.1 Handling Requirements

The Contractor shall receive a shipping cask containing from up to 12 Core 2 fuel elements (nominal count is 12) in a carbon steel canister in accordance with the attached Shipping Cask and Fuel Receipt Schedule (Attachment D). The Contractor shall remove the Core 2 fuel elements from the carbon steel canister, package the fuel in accordance with 4.3.4, and place the fuel in the Contractor's storage system to meet the conditions of the NRC license. The Contractor shall inspect, inventory, treat, and/or condition the individual fuel elements, as necessary, to meet this specification and the Contractor's NRC licensing conditions for dry storage and transportation. The facility design and license shall include the capability to receive, handle, unpackage, repackage, and store broken Peach Bottom Core 2 elements. The Contractor shall dispose the carbon steel canisters in accordance with the 4.3.7, "Waste Management."

4.3.6.4 Training, Research, Isotope production, General Atomics (TRIGA)

TRIGA fuel rods under this contract consist of uranium-zirconium hydride, and the cladding is constructed of aluminum or stainless steel. TRIGA fuel continues to be brought to the INEEL from domestic and foreign sources. The scope of this contract includes 1600 TRIGA elements. The fuel assembly is generally 28.94 inches in length by 1.48 inches in diameter depending upon the end

fixtures designed for each user. Fuel arriving at the INEEL from off-site sources has likely been stored in water for some time, but will be placed in dry storage within the IFSF upon arrival at the INEEL. The assemblies may have experienced some corrosion, but the fuel itself is expected to be in good condition. Greater fuel description and detail is provided in Attachment A (Fuel and Package Descriptions) of this General Specification.

The TRIGA SNF shall be 1,285 Standard (stainless steel) elements, and 315 Aluminum elements.

4.3.6.4.1 Handling Requirements

The Contractor shall receive from 18 TRIGA fuel cask shipments, in accordance with the attached Shipping Cask and Fuel Receipt Schedule (Attachment D). The Contractor may use the fuel cans (containing up to 5 fuel elements) for placing the fuel into the storage system provided this meets the requirements of the NRC license and provided the fuel canisters are used in connection with the packaging requirements of 4.3.4. The Contractor shall inspect, inventory, treat, and/or condition the individual fuel elements, as necessary, to meet this specification and the Contractor's NRC licensing conditions for dry storage and transportation. . The Contractor shall return all empty TRIGA fuel cans (unless used in the repackaged configuration as allowed above), buckets and canisters to DOE in the same condition they are received by the Contractor .

4.3.7 Waste Management

4.3.7.1 Waste Streams

There are several wastes that may be generated under this Contract. Primary wastes include original fuel storage canisters, cans, liners, baskets (fabricated from either aluminum, carbon steel or stainless steel), fuel end hardware, and other hardware and non-fuel materials received from DOE with the fuel shall be processed and packaged to meet the requirements of the INEEL Reusable Property, Recyclable Materials, and Waste Acceptance Criteria (RRWAC), Section J Attachment H and returned to DOE for disposal at no charge to the Contractor. All process generated wastes (e.g., tools, lead shielding, laboratory analysis waste, decon/washdown solutions, and miscellaneous radioactive waste items such as used anti-c clothing) resulting from Contractor operations shall be the responsibility of the Contractor to properly treat, store and dispose. Process generated wastes which meet the INEEL RRWAC may be dispositioned through the INEEL at the rates defined in Section J. The Contractor shall handle, treat, and package these and any other wastes in accordance with the applicable regulations and waste acceptance criteria. The facility processes and equipment shall be designed to limit solid waste generation. Liquid and hazardous waste will not be accepted by DOE and shall be the responsibility of the Contractor to

properly treat, store and dispose.

4.3.7.2 Contractor Responsibilities

For those wastes to be returned to the INEEL, the Contractor is responsible for ensuring compliance to the INEEL RRWAC. The Contractor shall contact the assigned INEEL Generator Interface to ensure all requirements for characterization, packaging, and receipt are identified and met. The name, telephone number and location of the INEEL Generator Interface will be made available upon request. The Contractor shall ensure that the material form, package, and documentation adhere to these criteria. The Contractor shall ensure that requirements for transport, and the requirements contained in any applicable transport plan or certificate of compliance, are adhered to before shipment.

The Contractor shall be responsible for maintaining an auditable waste minimization program. Waste will not be received by INEEL receiving organizations from the Contractor without an auditable waste minimization program. The Contractor shall document the program following a Pollution Prevention/Waste Minimization Plan (PP/WMP). This plan shall be transmitted to DOE.

4.3.7.3 Waste Characterization

The Contractor shall characterize and analyze all waste generated prior to requesting shipment to DOE or an offsite facility. The Contractor's characterization process shall provide verifiable evidence of compliance to the applicable acceptance criteria. Characterization shall be planned and performed in close coordination with DOE or offsite facility waste generator interface personnel. The Contractor shall maintain appropriate records, statements, reports, and data that support characterization. Section J, Attachment J-K identifies deliverable documentation.

4.4 Architectural Requirements

Building and architectural systems shall meet the requirements of ANSI/ANS-57.9 and applicable standards identified by the Contractor in the Requirements Document and approved by the contractor. As a minimum, non-nuclear safety equipment, systems, processes, components, and structures shall comply with the DOE-ID Architectural Engineering Standards, Section J, Attachment J-D.

4.4.1 General Architectural

The Facility shall include the following:

- Security Control Point
- Office and support areas for facility personnel

- Ready Room to be used as a break room and to conduct meetings
- Document Control (for storage of documents and drawings)
- Men's and women's lavatories, including lockers, and change facilities
- A Radiation Control office and change room with decontamination showers
- Telecommunications room
- General storage room or closet
- Janitor room or closet
- Office areas shall be provided with lighting, electrical receptacles, local area network and telephone.

4.4.2 Building Features

Where wash-down or decon activities are to be located the floors shall be sloped to drains and have unobstructed draining capabilities for any water. Liquid waste shall be collected in holding tanks and tested prior to being emptied.

The interior wall of areas where potential contamination may be found shall be sealed with a coating that allows for decontamination. Hot Cells shall include shielded and decontaminable walls, floors and ceilings as appropriate for remote handling devices. Shielded operating galleries shall be provided for the conduct, control, and monitoring of remote handling operations. The gallery designs and layouts shall address operator ergonomics and safety principles.

Facilities for donning and doffing Anti-C clothing shall be located adjacent to contamination areas. A buffer area shall be provided for personnel entering and exiting contamination areas and shall include space for discarded protective clothing and a step-off pad for frisking of contamination by Personnel Contamination Monitor. All surfaces in the buffer area, as well as the floors and walls of the Anti-C room, shall be capable of being decontaminated..

Each entrance or access point into a high radiation area (>100 mr/hr at 30 cm) shall have either a control device that energizes a conspicuous visible/audible alarm signal whenever entry is made, or have entryways that are locked, except during periods when access to the areas is required. Such systems shall comply with egress safety requirements.

The facility HVAC systems shall provide temperature conditioning and filtration of supply air and provide pressure control. The system shall collect exhaust air from contamination control areas and pass the air through HEPA filters before discharging to the atmosphere. Fire detection and suppression for the HEPA filters shall be provided in accordance with NFPA 801. The HVAC-controlled environment shall maintain differential pressures from area to area by containment barriers and sealable entries to prevent the spread of contamination. Air shall flow from areas of least contamination to areas of highest contamination potential. Doors for all occupancies shall meet the requirements for areas having area openings to maintain pressure, shielding, and containment barrier separation. Mechanical operator devices and

inflatable seals shall be installed at containment barriers. A method for eliminating truck exhaust fumes shall be provided.

The design of the fire protection system for the facility shall comply with the DOE-ID AE Standards. Firewater can be supplied by DOE as described in Section J Attachment C. The fire alarms for this facility will be connected to a THORN fire alarm control panel, which will be connected to a MINI-100 20 ma fire alarm communication panel. Two fiber optic circuits (4 total) will be connected to the existing fiber optic loop at INTEC. A multiplexing panel (MP 25) is presently located in INTEC Building CPP-665. Programming at the INEEL Central Facilities Area fire alarm dispatch center will be completed by the INEEL Life Safety Systems (LSS) organization. The LSS organization will be responsible for fire alarm certification and all maintenance and configuration control of the system outside of the Contractor's facility. The Contractor is responsible for these same activities within the Contractor's fence. DOE must be notified in advance of any planned work on or testing of the fire protection system or planned use of fire water. DOE will route the cables/wiring (with excess length to reach the Contractor's operations control building) for the connection of the communications and alarms systems to the Contractor's site boundary. The Contractor is responsible for all routing of this cable/wiring, and terminations (except as noted for the security system) within the Contractor's site. DOE will make final terminations at the INTEC facilities.

4.5 Civil Requirements

The following features shall, as a minimum, meet the general requirements of the DOE-ID Architectural Engineering Standards, Section J, Attachment J-D.

4.5.1 Surface Drainage

The Contractor shall coordinate the facility's surface drainage with the INTEC Surface Drainage System. The INTEC Surface Drainage System is shown on drawing 094253. A copy of the drawing is attached to Section J, Attachment J-G. Run-off from the DTF and ISFSI and systems shall be diverted to ditches consistent with INTEC controls.

4.5.2 Slabs, Sidewalks, and Stoops

Reinforced concrete sidewalks, door stoops, and approaches shall be provided to facilitate personnel and vehicle access to the DTF and ISFSI. Building utility and equipment pads shall be of reinforced concrete and sized to accommodate appropriate loading.

4.5.3 Fencing

Perimeter fencing surrounding the DTF and ISFSI to meet security requirements

(5.1 of this Specification) shall consist of galvanized, pipe-supported, 11-gauge steel fabric with 2-in. mesh openings. A 20-ft. clear zone shall be maintained on each side of the fence. Three strands of barbed wire on a single 45-degree arm, angled outward, shall top fencing. Top rails shall be continuous along the top edge of the fence fabric. All installed fence hardware shall be peened or spot-welded. The overall fence height, excluding barbed wire shall be 8 ft. The fence shall be grounded.

4.5.4 Paving

Paving shall be provided for the storage area, around the building, for parking areas, and for the access roads. Roadways shall be a minimum of 15 ft wide. The basemat for the storage system, approach slab, and roadways shall be designed to accommodate the maximum loads projected during the loading and operation of the ISFSI.

4.5.5 Sanitary Waste

The Contractor's sanitary waste system may be connected to the existing INTEC system for disposal of raw sewage. The Contractor shall provide all necessary data to obtain necessary permits or permit modifications for this system. This system shall not be used for disposal of any industrial waste streams or other waste streams that potentially may be contaminated with radiological or hazardous constituents.

4.6 Electrical Requirements

The following deliverables shall, as a minimum, meet the general requirements of the DOE-ID Architectural Engineering (AE) Standards, Section J, Attachment J-D.

4.6.1 Power

The electric power system shall provide for the operational electrical supply needs to operate all mechanical, electrical, instrumentation, lighting, communications, and physical security systems. Emergency and standby power shall be provided as required to maintain safety systems as described in the conditions of the NRC license.

An Uninterruptable Power Supply (UPS) shall be provided to furnish emergency power to the Fire Alarm, Voice Paging, HVAC, Radiation Monitoring and Alarm, and security systems. There shall be sufficient battery capacity to carry the rated load in accordance with NFPA 72.

4.6.2 Grounding

An isolated grounding system shall be provided. The following equipment shall be bonded to the ground loop: facility steel, water

piping, support equipment, distribution equipment and motor frames.

4.6.3 Cathodic Protection

Any utility piping with the potential for corrosion shall be protected through connection to a cathodic protection system to be provided by the contractor. A testing station shall be included to periodically monitor the cathodic protection system.

4.6.4 Lighting

Lighting shall be designed and included in accordance with current Illuminating Engineering Society (IES) recommendations and to meet NRC security requirements.

4.6.5 Lightning Protection

A lightning protection system shall be provided to meet NRC requirements.

4.6.6 HVAC Controls

A HVAC control system shall be provided. It shall be a smart system that can automatically generate control signals to change HVAC equipment operating parameters based on signals received from various monitors. A computer monitor shall be provided in the operations control area for reviewing the operating status of the system and making adjustments to control setpoints.

Instrumentation shall be provided to detect and alarm both high and low differential pressures across filters in the HVAC system.

Safety systems shall perform their functions under all design basis accident conditions.

4.6.7 Radiation Monitoring and Alarms

Radiation detection instrumentation shall be provided to warn operating personnel of radiation and airborne radioactivity levels above set limits.

The RAMs shall alarm locally and remotely in the operations control area.

An alpha CAM shall be located in the inlet duct to the HEPA filter for the HVAC system.

A Criticality Alarm System shall be provided.

Continuous stack monitoring shall be provided for the detection of radioactive particulate in the air exhaust stream.

Provision shall be made in the design for leak detection for any water collection or storage tanks.

Area monitoring instruments shall transmit data to a microprocessor-based system for display, recording, alarm, and trending in the operations control area.

4.6.8 Communications and Alarms

Voice and data telecommunications lines shall be provided throughout the occupied areas of the facility.

The existing INTEC Broadband Local Area Network (LAN) shall be made available in the facility. Access ports shall be provided in all normally occupied offices.

Emergency voice paging and alarm systems (fire, radiation, criticality, evacuation, security) shall be tied into existing systems at INTEC and connected to a panel alarm system located in the Contractor's operations control office. The specifications for these systems in the DOE-ID AE Standards shall be used to ensure compatibility with existing INEEL systems. The Contractor must install a FAST-brand Remote Distribution Module (RDM) for their facilities. A parts list for the FAST RDM system presently in use at INTEC is included as Section J-G-G. With the exception of the security system, the Contractor shall be responsible for all installation and connections of communications and alarms systems within the Contractor's site. Interface drawings are provided in Section J Attachment J-G.

5.0 OTHER GENERAL REQUIREMENTS

5.1 Safeguards and Security

The Contractor shall provide safeguards and security for the DTF and ISFSI in accordance with 10 CFR Part 72. This includes all NRC requirements such as Emergency Planning, Radiation Protection, Fire Protection, Security Program, Environmental Monitoring, Certified Fuel Handler Program, and Quality Assurance Programs. Existing INEEL site systems (emergency brigade, fire department, and security) will be made available for use in these activities except for the physical safeguards and security requirements within the Contractor's facility. If performance testing of the INEEL Protective Forces is required as an NRC License condition, the Contractor may obtain these INEEL personnel services at the rate specified in Section J

Attachment J-C of this contract.

The Contractor shall provide all security and safeguard systems within the fenced boundary of their facility, as required to meet licensing conditions, during the contract performance period. These systems shall be compatible with and report to the existing on-site INEEL security system and services. All alarms and access control systems shall be tied into the INEEL security system. The INEEL uses the ARGUS security system; configuration control of the ARGUS system is managed by Lawrence Livermore Laboratory. Specific features of this system are sensitive and are not provided in this document. Tie-ins to the INEEL security system will be made by DOE.

Close coordination with the INEEL Security organization will be required during the Contractor's design phase to ensure security system compatibility. The Contractor shall provide information to DOE concerning security, safeguard systems interfaces, and compatibility during the design phase.

The INTEC site configuration and SNF Contractor facility area is shown on drawings in Section J-G. The Contractor shall provide all necessary fencing and gates for this facility. Security features for any fencing or gates shall be compatible with the INEEL security system.

The Contractor shall establish access control and accountability to their site. This includes any card readers, vehicle barriers, and other measures necessary to meet NRC requirements.

DOE will provide one (1) ARGUS Field Processor with power supply and one (1) Remote Access Panel as Government Furnished Equipment under this contract. The Contractor shall install this equipment. The ARGUS Field Processor is a multiplexor with a capacity of 48 alarms and 8 card readers. If additional capacity is needed, the Contractor shall notify DOE early in the design process. The Contractor shall locate the ARGUS Field Processor and Remote Access Panel within the Contractor's facility in accordance with the final design. DOE will make the final connections of the multiplexor to the INEEL Central Alarm Station.

The Contractor shall provide all access control devices, alarms, cameras, lighting, sensors, keys, locks, and other security equipment as required to meet NRC requirements. This equipment must be compatible with the ARGUS system. The Contractor is responsible for installation of this equipment and associated cabling to the ARGUS Field Processor. DOE will make final cable terminations at the multiplexor.

The Contractor is responsible for all maintenance of the installed security equipment internal to the contractor's facility except the multiplexor. Preventive and corrective maintenance to the multiplexor will be provided by DOE at no cost.

5.2 Material Control and Accountability

The Contractor shall provide a data management system to keep records showing the receipt, inventory (including location), and transfer of all SNF in the Contractor's possession. This system shall comply with NRC requirements for material control and accountability. The records shall include, as a minimum, the name of the fuel shipper, the quantity of radioactive material per item (including special nuclear material in spent fuel), item identification and serial number (must be the same as or maintain traceability to original DOE numbers), storage location, on-site movements of each fuel assembly and element, and ultimate disposition.

A copy of the DOE/NRC forms 741/741 A (Nuclear Material Transaction Reports) and forms 742 and 742C (Material Balance Report and Physical Inventory Listing) shall be provided to DOE in accordance with the contract deliverables schedule, at the time they are provided to NRC.

Backup records shall be maintained to ensure an off-normal event cannot result in the loss of the sole records of SNF inventories. The backup system shall be located at a location off of the INTEC site (to prevent loss in the case of a single event). These records for spent nuclear fuel shall be retained for as long as the material is stored, and for a period of five years after the material is disposed of or transferred out of the ISFSI.

Equipment shall be provided to enable the conduct of a physical inventory, of all spent fuel and high-level radioactive waste in storage, at intervals not to exceed 12 months, unless otherwise directed by the NRC requirements. A copy of the current inventory at the time the ISFSI is loaded shall be retained as a record until the NRC terminates the license.

Emergency voice paging and alarm systems (fire, radiation, criticality, evacuation, security) shall be connected to existing systems at INTEC and connected to a panel alarm system located in the Contractor's operations control office. The specifications for these systems in the DOE-ID AE Standards shall be used to ensure compatibility with existing INEEL systems. With the exception of the security system, connections to the INEEL systems shall be the responsibility of the Contractor. Interface drawings are provided in Section J Attachment J-G.

5.3 Environmental, Safety and Health

DOE is the responsible agency with regulatory authority for INEEL operations for on-site worker safety and health. Under this contract, NRC will regulate the nuclear safety and DOE will regulate other workplace hazards at the Contractor's site. The Contractor shall develop and submit to DOE for approval the Environmental Safety and Health Program Operating Plan (ESHPOP), which shall govern activities during construction and operations that are not regulated by NRC. This plan shall be approved by DOE prior to start of on-site construction activities. The ESHPOP shall define the baseline ES&H requirements and shall be incorporated into the contract. Any changes will be negotiated in advance between the Contractor and DOE-ID. ES&H information in other formal permits (such as state air or RCRA permits) and licenses need not be

duplicated in the ESHPOP, but shall be presumed to be included in the baseline ES&H requirements. The Contractor shall develop the appropriate safety basis definition, associated safety requirements, and surveillance actions. The Contractor shall obtain all necessary permits and abide by all applicable laws, regulations and ordinances of the United States and of the state, territory and political subdivision in which the work is performed. The Contractor shall design and operate their facilities within the envelope established for this project by the DOE Programmatic SNFEIS, the NRC NEPA documentation, and permits. The contractor shall provide copies of annual facility emissions reports to DOE for information as identified in Section J Attachment K.

5.4 Project Management Plan

The Contractor shall develop, submit, and implement a Project Management Plan that conforms to the Contract requirements. The plan shall demonstrate the Contractor's ability to successfully manage and complete the work and shall define essential personnel. As a minimum, the Project Management Plan shall contain the following information:

- Management Organization and Responsibilities
- Work Plan
- Work Breakdown Structure
- Schedule
- Logic Diagram
- Project Performance Information and Reporting
- Configuration Management Control
- Internal and External Interfaces, including roles and responsibilities, shall be documented for all phases of the project

5.5 Drawings

Computer-aided design (CAD) incorporating simplified drafting practices shall be used in the preparation of drawings. Drawing methods and standard symbols shall be in accordance with ANSI standards.

Drawing prints shall be black or blue line on white paper of good print quality and durability. Drawings shall be completed on AUTOCAD software version 14 or newer. Drawings and specifications shall be maintained current through the life of this contract. The Contractor shall provide complete designs and updates in accordance with submittals under the Section J, Attachment J-K "Deliverables." Electronic copies of drawings shall be in DWG format and placed on high-density diskettes.

5.5.1 As-Built Drawings

Upon completion of construction, the Contractor shall update the drawings, specifications, and all other vendor data to reflect the "As-Built" conditions of the DTF, ISFSI, utilities, and all support systems and equipment. The original

drawings and the title page of each specification shall be stamped or marked (in reproducible quality) with the words "As-Built" at or near the bottom of the sheet. All as-built drawings shall be field verified by the Contractor to be accurate.

Drawings and specifications shall be maintained current through the life of this contract. Updates to the "As-Built" documentation shall be provided as changes are made through the life of the contract. The Contractor shall furnish the "As-Built" design drawings and specifications in accordance with Section J, Attachment J-K.

5.6 Vendor Data

The Contractor shall maintain all essential data to document full compliance with the contract. The data shall confirm the technical and safety bases for the facility. The Contractor shall maintain data needed to establish a history for the DTF and ISFSI, traceable to essential equipment, materials, and processes such as non-destructive examination, inspections during construction and testing to meet NRC QA requirements. The data shall provide all essential information needed to license, update or transfer the license, operate and maintain the DTF and ISFSI safely and in accordance with all applicable laws and regulations.

5.7 Equipment Identification

All buildings, structures, equipment, pipelines, valves, instruments, panels, junction boxes, and vessels at the INTEC shall have unique (INTEC assigned) identification numbers. The equipment numbers shall be shown on the Contractor's drawings. The Contractor shall prepare and submit a general list of the equipment in accordance with the Submittals and Deliverables Schedule section of the Contract. The DOE will assign a block of identification numbers for use by the Contractor.

5.8 Parts

The Contractor shall provide, and have available, spare parts required to maintain safe, continuous operation of the DTF and ISFSI. A list of the types and quantities of spare parts shall be provided to DOE prior to operating the facility. This list shall include the name of the manufacturers and part number for each part.

5.9 Operating Procedures and Technical Specifications

The Contractor shall prescribe and implement operating and maintenance activities by documented procedures, specifications, or drawings of a type appropriate to the circumstances and shall require that these procedures,

specifications, and drawings be followed. The procedures, specifications, and drawings shall include appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished. Existing procedures associated with government furnished equipment will be provided to the Contractor by DOE.

5.10 Pre-Operational, Startup and Performance Testing

5.10.1 Definitions

Startup: The series of activities required to prepare the DTF and ISFSI for the operations phase (Phase III of this Contract). These activities include, but are not necessarily limited to:

- Testing (as a minimum, the activities detailed in 5.10.2)
- Operator Training (to meet NRC requirements)
- Readiness Reviews (to meet NRC requirements)
- Documentation of readiness reviews and assessments reports.

Start of Operations: The beginning of Phase III of this Contract. All startup activities shall be completed prior to “start of operations.”

5.10.2 Testing Requirements

The Contractor shall prepare test and startup procedures, perform testing, and provide documentation demonstrating the functional and operational readiness of the systems and components for all fuel types prior to the start of operations. In addition, the Contractor shall satisfy all NRC licensing commitments and conditions prior to the start of operations. All equipment provided, including equipment that will be used by the Contractor for future operations, shall be demonstrated to meet functional requirements prior to start of operations. As a minimum, testing shall include:

- Pre-Operational Tests of individual components
- Pre-Operational test of Systems (System Operational Tests)
- Startup and Performance Demonstration Tests
- A Performance Demonstration Test shall be conducted as part of the Start-up testing. The facility Start-up includes the Contractor’s receipt of formal notification of the NRC’s approval to begin nuclear operations, and the successful loading of an IFSFI storage unit with a minimum of two standard canisters of Peach Bottom

Fuel. DOE will deliver 36 Peach Bottom Fuel Handling Units (FHU) to the facility for processing under Phase II. The Contractor may request additional Peach Bottom fuel deliveries if necessary to support their Phase 2 processing scheme. The Peach Bottom FHUs will be received and processed in the DTF, demonstrating all standard-processing operations. Two standard canisters must be fully loaded with Peach Bottom Fuel and placed in the ISFSI storage unit as part of Phase II. In the event the Contractor has requested more than 36 FHUs delivered to support Start-up, Phase II will be judged complete when the second fully loaded standard canister is in place in the ISFSI. DOE will make fuel available on a schedule to support this performance demonstration test.

SECTION C

Attachment C-A-A

Fuel and Fuel Package Descriptions

July 2002

Attachment C-A-A

Fuel and Fuel Package Descriptions

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1.0 PEACH BOTTOM UNIT I

1.1 Introduction

The Peach Bottom Unit 1 reactor was a High Temperature Gas-cooled Reactor (HTGR) that utilized graphite, uranium carbide, and helium coolant to achieve power production at a rated capacity of 115 MW(t). It was located at Peach Bottom, Pennsylvania, and operated with two different cores (Core 1 and Core 2) from 1966 to 1974. The reactor contained 804 fuel elements per fuel core load. The total number of fuel elements irradiated in the core was 1,639, which exceeds the total capacity of the two different core loadings because replacement and test fuel assemblies were added during operation of the cores. The graphite-based fuel elements were 3.5 in. in diameter and 12 ft. in length, containing varying amounts of uranium and thorium. These heavy metals were present as carbon-coated uranium carbide and thorium carbide particles that had been formed into compacts by sintering with carbonaceous materials.

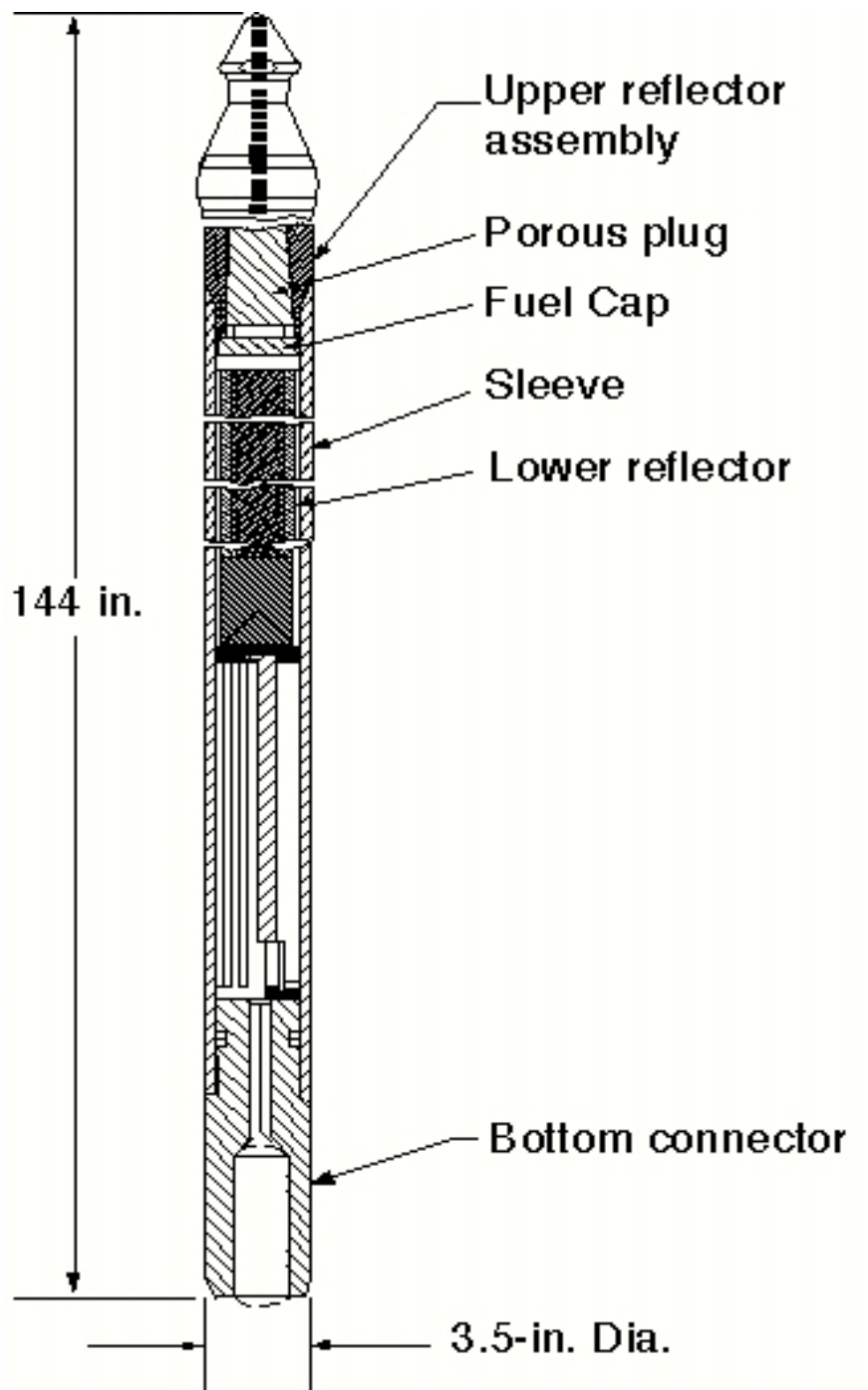
The design burnup of the fuel was ~73,000 MWd/MTIHM (megawatt days per metric tons initial heavy metal); however, excessive fuel failures during operation of Core 1 resulted in removal of that core at about half the design burnup. The fuel failure was attributed to the fuel particle coating system. This system was modified for the second core, which performed satisfactorily and reached design burnup. The reactor was shut down at this point. The total initial heavy metal loadings of the two cores were 1.686 and 1.419 MT of U + Th, respectively.

1.2 Physical Description of Fuel

The basic fuel element is a solid semi-homogeneous type in which graphite served as the moderator, reflector, cladding, fuel matrix, and structure. Each fuel element consists of an upper reflector assembly, a fuel bearing middle section, a lower reflector, and an internal fission product trap. The fuel materials, part of the lower reflector, and the fission product traps are contained in a sleeve of low-permeability graphite that joins the upper reflector on one end and a bottom connector fitting on the other (see Figure 1-1). A stainless steel screen installed at the bottom of each fission product trap retains any charcoal granules that might be released from the graphite body of the internal trap. Within the sleeve, the mixture of fissile and fertile materials making up the fuel is contained in annular compacts stacked on cylindrical graphite spines.

Three basic fuel element configurations were irradiated in both Peach Bottom reactor cores; standard fuel elements, instrumented fuel elements, and test elements. Each core contained a number of fuel elements that were instrumented with thermocouples and (in Core 1 only) acoustic thermometers. Thirty-six instrumented elements were included in the 804 fuel elements required for each core loading. In addition, 33 fuel test elements were irradiated in Core 2 to various exposures; the purpose of this was to measure the thermal, physics, fission product, and materials' behavior of commercial HTGR fuel concepts utilizing test assemblies in a representative commercial HTGR neutron spectrum and a helium coolant environment. Most of the test elements were removed and destructively analyzed at either General Atomics

(GA) or Oak Ridge National Laboratory (ORNL). Further descriptions of the Peach Bottom fuels are contained in references in Section J, Attachment J-L.



Peach bottom assembly

J96 0201

Figure 1-1. Standard Peach Bottom Unit 1 Assembly

1.2.1 Core 1 Standard Fuel Elements

The Core 1 standard fuel element has as its primary components a bottom connector, a sleeve, a screen, an internal fission product trap assembly, a lower reflector piece, fuel compacts, spines, burnable poison compacts (in selected elements), a fuel cap, and an upper reflector assembly. The bottom connector and the sleeve are joined by a silicon braze, and together they form the main barrier against fission-product leakage from the fuel element. The fuel cap is a graphite disk that slips loosely into the upper end of the sleeve. All three of these components (bottom connector, sleeve, and fuel cap) are made of graphite, which has a helium permeability of $3 \times 10^{-3} \text{ cm}^2/\text{s}$ or less and an effective permeability to gaseous fission products of approximately $10^{-5} \text{ cm}^2/\text{s}$ at reactor conditions.

The screen, internal trap assembly, lower reflector piece, fuel compacts with spines, and fuel cap are stacked, in that order, within the sleeve. The bottom connector supports the weight of these components. The lower reflector piece is a 3-in.-long graphite cylinder made of reactor-grade graphite. The annular fuel compacts are stacked on the cylindrical graphite spine sections. These spine sections are approximately 30 in. long and about 1.75 in. in diameter. There are two types of spines: one made of solid graphite and one with a 0.89-in.-diameter hole designed to contain burnable poison compacts. The screen, which is used to retain any charcoal granules that might be released from the graphite body of the internal trap, is made of 18-8 stainless steel.

The upper reflector assembly is a machined graphite component that is threaded and cemented into the sleeve of the fuel element. The cement consists of furnace-cured carbonaceous material. The upper end of the reflector piece is machined to engage with the fuel handling machines. A 0.25 in.-diameter hole down the centerline of the reflector serves as an inlet channel for purge gas. A porous plug cemented and retained within the upper reflector provides a controlled pressure drop for inflowing purge gas.

The Core 1 fuel compacts consisted of carbides of uranium enriched to 93.15% ^{235}U at the beginning of life (BOL) and thorium, uniformly dispersed as coated particles in a graphite matrix. The total carbon within the carbide substrates was between 11 and 16%, by weight, at BOL. The pyrolytic carbon-coated particles were between 210 and 595 μm in diameter, with coating thicknesses of $55 \pm 10 \mu\text{m}$. The size distribution of the particles was designed to ensure that the volume fraction of the coated particles did not exceed 30% of the total compact volume.

1.2.2 Four Types of Standard Fuel Elements

There are four basic types of standard fuel elements, which differ in their uranium, thorium, rhodium, and boron content. All other physical dimensions are the same for each element. To achieve the four different fuel element types each element was loaded with four distinctly different types of compacts. Each compact contained different levels of uranium, thorium, rhodium, carbon, and boron. The different fuel compacts are described in Table 1-1.

Table 1-1. Fuel Compact Loading (in grams)

Compact Type	A	B	C	D
Description	Standard	Heavy Rhodium	Light Rhodium	Heavy Thorium
Th ²³²	52.10	52.10	52.10	115.36
U ²³⁴ *	0.156	0.156	0.156	0.082
U ²³⁵	9.70	9.70	9.70	5.14
U ²³⁶ *	0.052	0.052	0.052	0.028
U ²³⁸	0.505	0.505	0.505	0.268
Rh ¹⁰³	0	1.028	0.342	0
Carbon	285.00	285.00	285.00	273.00

*²³⁴U and ²³⁶U loadings were not required. These were the maximum amounts expected in the fully enriched fuel material.

By stacking the four different types of compacts (Types A, B, C, or D) and the burnable poison compacts in different configurations inside each graphite fuel element, four distinct types of fuel elements were created. The four types of fuel elements, based on nuclear properties, which were required for the Peach Bottom Unit 1 reactor were designated as Types I, II, III, and IV. These four different element configurations are described in Table 1-2.

Table 1-2. Types of Fuel Elements Based on Nuclear Properties

Fuel Element Type				
Description	I Heavy Rhodium	II Light Rhodium	III Light Rhodium with burnable poison	IV Heavy Thorium; Light Uranium
Spine	Solid Graphite	Solid Graphite	Hollow with poison compacts	Solid Graphite
Compact Type:				
- In upper 9 inches	A	A	A	D
- In middle 54 inches	B	C	C	D
- In lower 27 inches	A	A	A	D
Number of types in a nominal core loading	54	588	60	102

1.2.3 Instrumented and Test Elements

Further information on instrumented and test fuel elements is contained in references provided in Section J, Attachment J-L. Four test elements are included in the scope of this contract. A total of

36 fuel elements were instrumented in the cores with two thermocouples each and (in Core 1 only) eight of these elements containing acoustic thermocouples. The acoustic thermocouple is an instrument, which utilizes the proportionality between resonance frequency of a transmitted sound wave and the temperature of the helium gas in a cavity within the fuel element to determine the temperature. The axial and radial location of the thermocouples varied, depending upon the planned position of the specific fuel element location in the core. The number of instrumented elements in each fuel element type is described in Table 1-3.

Table 1-3. Number and Type of Instrumented Fuel Elements

Number of Instrumented Fuel Elements	Type of Fuel Element	Use of Thermocouples
8	I & II	Spine and sleeve temperature. Also an acoustic thermometer at center, hot spot height (Core 1 only).
3	I	Axial profile at center of core - Spine temperature.
5	I, II, III, & IV	Radial profile - Spine plus internal trap inlet temperature.
7	I, II, & III	Radial profile - Both TCs for spine temperature.
3	II	Both TCs for spine temperature.
2	IV	Low uranium loading - Both TCs for spine temperature.
2	I & II	Internal trap inlet and outlet temperature.
2	II & IV	Standoff and bottom reflector temperature.
3	II	Axial profile at edge of core - Spine temperature.
1	III	Boron loaded - Both TCs for spine temperature.

1.2.4 Core 2 Fuel Elements

The Core 2 standard fuel elements were essentially the same as the Core 1 elements. The only design difference was in the coated particles and the external appearance of the fuel compacts. The coating of the Core 2 fuel and fertile particles consisted of an inner coating of low-density pyrolytic carbon surrounded by an outer isotropic layer of pyrolytic carbon ("BISO" particle). The total coating thickness was between 90 and 130 μm . coated particles were -340 and 630 μm in diameter, respectively, for the fissile and fertile particles. The Core 2 compacts were smooth and had slots on the ends.

1.2.5 Poisons

Burnable poison compacts, cylindrical in shape, were placed in hollow spines of some of the fuel elements (Type 3 fuel elements). Each compact contained 0.436 ± 0.030 g of natural boron in the form of zirconium diboride pressed into a graphite matrix. The maximum particle size of the zirconium diboride was 100 μm .

The physical properties of a typical standard and instrumented fuel element are summarized in Table 1-4.

Table 1-4. Physical Fuel Configuration

Assembly Shape	Right cylindrical rod
Assembly Dim.	3.5" O.D. x 12' long
Compact Shape	Flat annular cylinders (A doughnut shape)
Compact Dimension	2.7" O.D. x 2.98" long. Center hole ~ 1.75" dia.
Assembly "Cladding" Material	Low-permeable Graphite and nuclear-grade graphite
Compact "Cladding" Material	None (Graphite matrix was not designed to be a cladding)
No. of compacts/assembly	30 compacts
Enrichment	93.15%
Active fuel length	89"-90"
Fuel Meat	UC,ThC particles
Particle Cladding	Pyrolytically deposited carbon (PyC). Monocoated
Particle Cladding thickness	55 +/-10 μm
Particle Diameter	between 210 and 595 μm
Added material:	
Spines:	
- Solid spines, Dim.	~1.75" O.D. x ~30" long
- Hollow spines, Dim.	~1.75" O.D. x ~30" long (hole = 0.89" dia)
Burnable poison compacts	
- Shape	Solid cylindrical pellets
- Poison compact, Dim.	~0.89" O.D. x 2.0" long
- Poison material	ZrB ₂ particles pressed into a graphite matrix
- Poison particle diameter	~100 μm
- Stainless Steel Screen	18-8 SST
- Internal trap	Activated Charcoal
- Brazing ring	Silicon
- Thermocouple (Instrumented elements only)	Inconel sheath, tungsten-rhenium, chromel-alumel Nb-1% Zr sheath
- Bottom Connector (Instrumented)	Graphite, stainless steel, inconel

1.2.6 Current Location

The Peach Bottom 1 reactor was shut down on October 31, 1974, and all of the spent fuel was shipped to different facilities. The total inventory of spent fuel from the reactor consists of two cores (Core 1 and Core 2), some replacement elements, and a number of test elements. The total number of elements irradiated in both cores was 1639.

Most of the Peach Bottom Unit 1 spent fuel is stored at Idaho National Engineering and Environmental Laboratory (INEEL). All the spent fuel shipped to General Atomic Corporation for destructive analysis was subsequently shipped to the INEEL for storage. Of the twelve known elements shipped to ORNL for examination two of these were destroyed in the course of examinations and the remaining ten are in retrievable underground storage. This leaves 25 Peach Bottom Unit I fuel elements unaccounted for.

1.3 Packaging

Because of the different storage locations and dates of transportation, the fuel elements from each core were packaged differently. A description of how the elements from each core were packaged is discussed below.

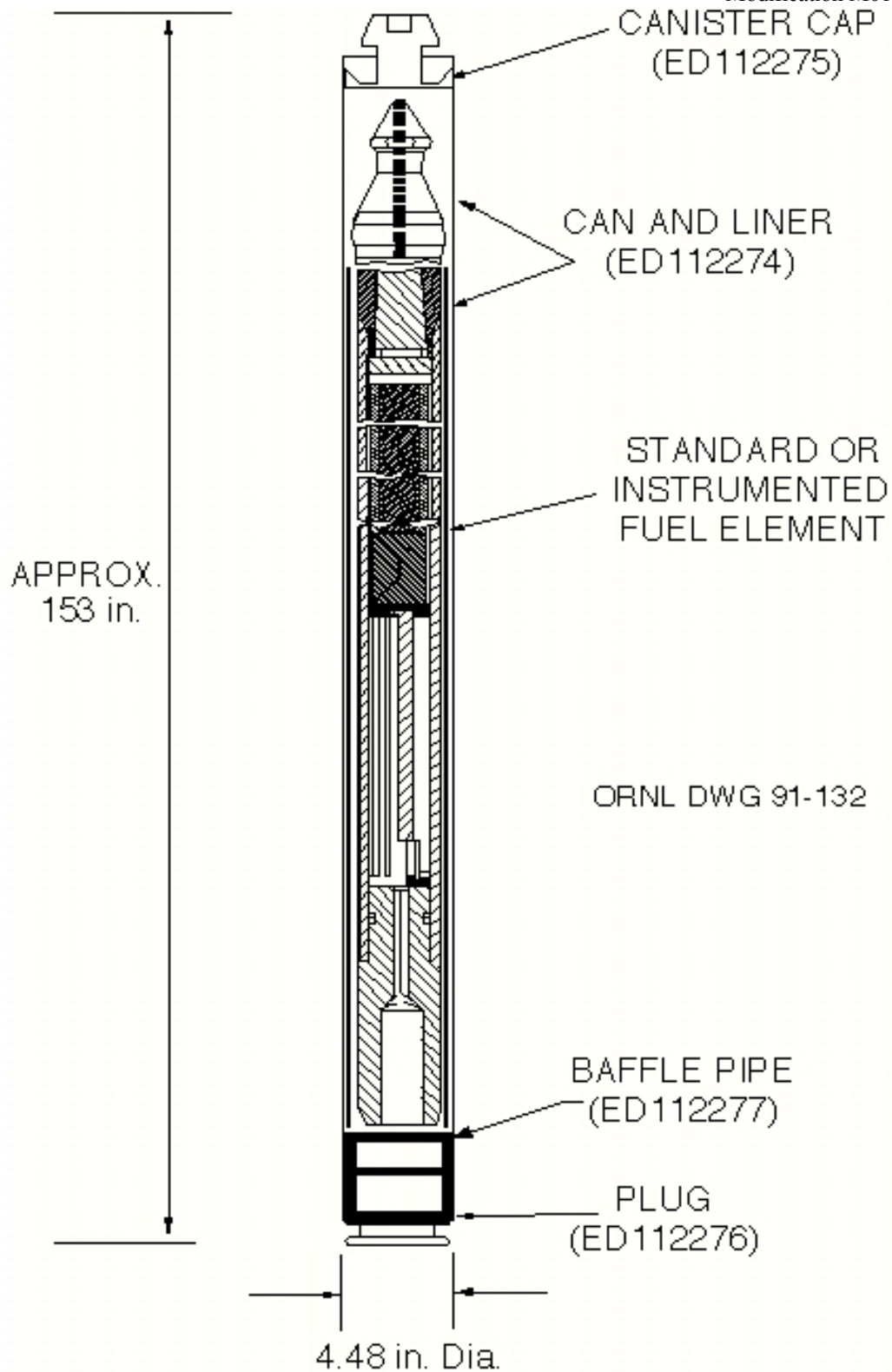
1.3.1 Core 1 Packaging

Core 1 is currently stored in open-field drywells at the CPP-749 Facility, and in the Fuel Element Cutting Facility (FECF) within CPP-603. These facilities are located within the Idaho Nuclear Technology and Engineering Center (INTEC) at the INEEL. The fuel was placed in sealed aluminum canisters with stainless steel liners at Peach Bottom after removal from the reactor. The failed fuel was removed from the core with a stainless steel failed fuel element tool, and both the tool and the element were placed in a sealed canister (see Figure 1-2). The sealed storage canisters were then back-filled with Helium and checked for leaks. If leaks were detected the entire canister and fuel element were then placed in a second aluminum storage canister called a salvage canister (see Figure 1-3). The typical loaded storage canisters weigh about 150 lb.

The canisters of fuel were shipped to the INEEL in the Peach Bottom fuel shipping cask. Eighteen elements at a time were positioned in the cask by means of a basket assembly. At the INEEL, an entire handling basket loaded with fuel canisters was lowered into a CPP-749 drywell. A loaded handling basket weighs a maximum of 5150 lb. Forty-six handling baskets are situated in individual drywells. Removal and canning of the failed Core 1 fuel resulted in a number of package types (fuel canisters) that were loaded into the handling baskets (see Table 1-5). All fuel is stored in their original handling baskets except for one new stainless steel basket. Further information on fuel packaging is contained in references provided in Section J, Attachment J-L.

1.3.2 Core 2 Packaging

Core 2 fuel elements are currently stored in unsealed, carbon steel canisters at the Irradiated Fuel Storage Facility (IFSF) within CPP-603 (see Table 1-6). The Core 2 spent fuel was packaged for shipment using canisters of the same type as those used for Core 1. However, instead of placing the fuel into similar drywells used for the Core 1 fuel, all the Core 2 fuel was stored in the IFSF. Since the carbon steel storage canisters are only 11 feet in length, once the fuel was received at the INTEC, the graphite fuel elements were removed from the aluminum canisters and the top reflector was cut from the tops of each element. The cropped elements were stored with up to 12 elements per carbon steel canister and the canisters were then placed into the IFSF. One storage canister contains four broken elements. Further information on fuel packaging is contained in references provided in Section J, Attachment J-L.



Peach Bottom Spent Fuel Storage Canister

Figure 1-2. Peach Bottom Spent Fuel Storage Canister

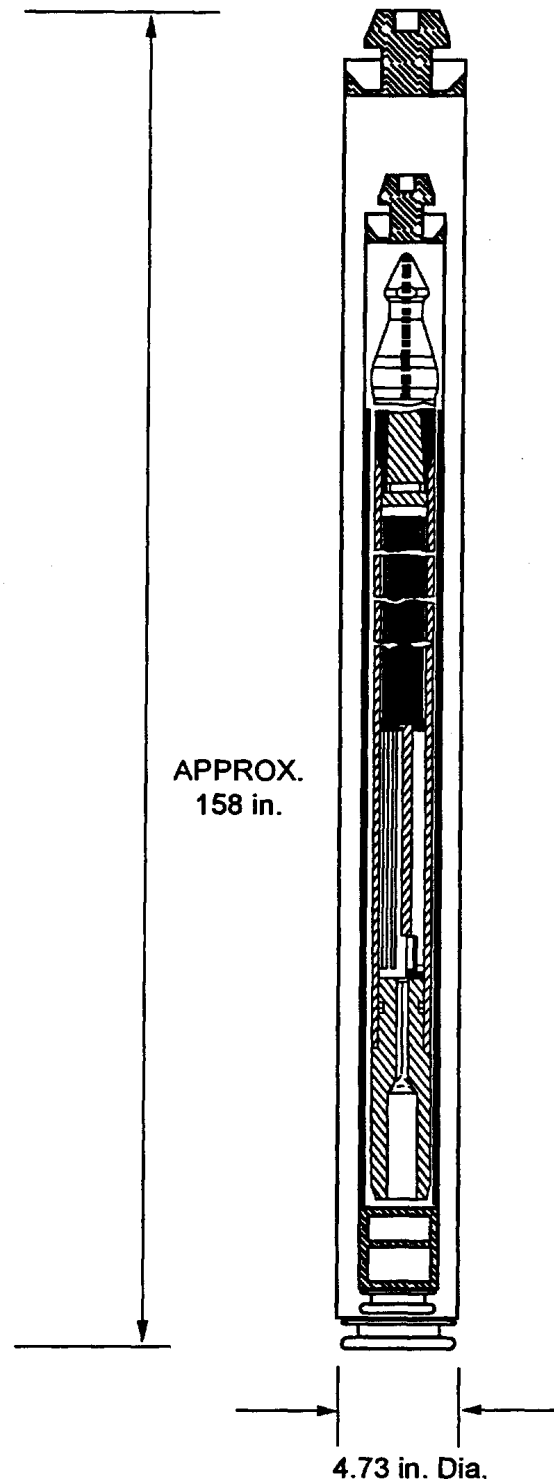


Figure 1-3. Failed Fuel Element in Storage Canister in Salvage Canister

Table 1-5. Peach Bottom Unit 1 – Core 1 spent fuel package types stored in CPP-749

Fuel package type	No. of elements	Description
1	528	Type I or II fuel element, regular can and liner
2	58	Type I or II fuel element, failed sleeve, normal can, slit liner, spacer, type 2 removal tool
3	7	Fuel Package type 2 with a type I removal tool
4	1	Type II fuel element (No. 263) broken and stored in 2 containers Upper portion of element with 21 compacts is in a salvage can with unmarked salvage cap with partial type 2 removal tool, special spacer, component canister, 4.25 in. Spacer, and 50 lb of steel shot Lower portion of element with 9 compacts is in a regular canister (cap No. 120) with a 3.25 in. spacer and a special GA pulling tool
5	1	Type II fuel element (No. 451), failed sleeve, normal can, split liner, spacer, type I removal tool. Due to leaking canister, recanned in salvage canister with special vented cap, unmarked
6	1	Type II fuel element (No. 576), failed sleeve, type 2 removal tool, component canister and spacer in salvage canister, cap No. 8
7	1	Type 2 Fuel Package in a salvage canister (cap No. 851, fuel element No. 731).
8	1	Type 2 fuel element (No. 848) less upper reflector canned in salvage canister (component canister and 4 in. spacer inside). Salvage cap is unmarked
9	71	Type III fuel element, regular can and liner
10	8	Fuel Package type 2 with a type 3 fuel element
11	1	Fuel Package type 10 with a hollowed out cap (No. 90) due to a removal tool positioned too high (element No. 126)
12	1	Fuel Package type 10 recanned in salvage canister with cap C5 (element No. 306)
13	1	Type 10 Fuel Package (element No. 870) in can No. 14 (cap unmarked) with type 1 removal tool
14	98	Type IV fuel element, regular can and liner
15	5	Type 2 Fuel Package with acoustic thermometer installed
16	1	Type 15 Fuel Package (fuel element No. 807 in can 01, cap unmarked with a type I removal tool.
17	1	Type 1 Fuel Package (fuel element No. 808 and cap No. 252R) with acoustic thermometer installed.
18	18	Type 1 Fuel Package with thermocouple installed.

19	3	Type 2 Fuel Package with thermocouple installed.
20	3	Type 9 Fuel Package with thermocouple installed.
21	4	Type 14 Fuel Package with thermocouple installed.

Table 1-6. Storage Locations and Configurations

Core 1 Configurations	
Aluminum storage canisters	
- Standard storage canister	4.48" O.D. x ~153" long
- Salvage storage canister	4.73" O.D. x ~158" long
Aluminum Storage Baskets	25.5" O.D. x ~158" long (Elements longer than basket)
No. of Elements in Baskets	Nominally 18 elements
Core 1 Locations	
- CPP-749	814 canisters containing 813 elements in 46 storage baskets
- IFSF	4 overpack canisters containing 1-1/2 elements
Core 2 Configurations	
No storage canisters	All elements were de-canned (Bare fuel elements)
IFSF carbon steel canisters:	18.0"O.D. x 129.0" long
No. of Elements in IFSF canisters	Up to 12 elements
Core 2 Locations	
- IFSF	787 elements in 70 IFSF storage canisters

1.4 As Stored Condition

1.4.1 Core 1

Core 1 contained fuel particles coated with a single layer of pyrolytic graphite. Dimensional changes caused by fast neutrons and damage due to fission product recoils resulted in cracking and distortion of the coatings on the fuel particles. The broken coatings, in the process of curling and changing dimensions, caused the compacts to distort and swell. The radial expansion produced in the compacts caused them to bind against the graphite sleeve, leading to fracture in some cases. A total of 90 elements in Core 1 developed cracked sleeves. Two elements were completely broken during core removal.

The fuel in the balance of the core remained intact and was removed and then packaged for disposal (see section 1.3.1). It can be assumed that most of the fuel particles have failed and most of the compacts have experienced swelling after their reactor experience.

Utilizing a small remote television camera and lights, visual inspections have been performed of the interior of the dry wells, the aluminum handling basket, and the aluminum fuel canisters containing the graphite fuels (see section 1.3) while in storage. Water has been seen to have entered the interior of the storage area causing corrosion of the basket bottoms, sides of the basket and fuel canisters, and the tops of the fuel canisters. Fairly large

corrosion deposits were visually recorded on the bottoms of the handling baskets and the tops of the fuel canisters. The extent of the corrosion to the handling basket and canisters varied for each drywell storage location. However, it is assumed that all storage configurations have been corroded to some extent. During removal of a basket for inspection during 1988, the basket failed. This was due, however, to improper handling and not corrosion. These fuel canisters were placed in a new stainless steel basket and stored in a second generation storage vault.

Not all of the individual fuel canisters have been inspected, so the extent of the damage to both the fuel canister and the fuel elements have not been determined. Water may have entered through the corroded canisters and have come in contact with the graphite fuel elements. The possible degradation effect on the graphite material from the water has not yet been addressed. The Peach Bottom baskets and canisters showing corrosion are stored in first-generation vaults within CPP-749.

To effect these transfers, a new support plate will be installed on the bottom of the existing Peach Bottom basket. The support plate prevents fuel cans from dropping through the bottom of the basket during handling should the corroded bottom fail. The support plate is connected to a rod that extends through the center tube of the basket. The connection is made remotely using the insertion tool to extend the rod through the penetration in the cask top lid, through the center position of the basket, to the new support plate below the basket, where it is threaded into place and torqued. This new rod also has a threaded lifting fixture at the top. A lifting rod can then be connected to the rod for restoring the fuel. The basket will continue to be relied upon to provide lateral support for the canned elements. The support plate (PLT-DSW-902-XX) has a diameter of 25-in. It is fabricated of $\frac{3}{4}$ -in. Type 304 stainless steel plate. The support rod is fabricated of $\frac{3}{4}$ -in Nitronic 60 with a length of 153.5 inches.

The Fuel Examination and Cutting Facility (FECF) at the CPP-603 Underwater Fuel Storage Facility contains two canned Peach Bottom Fuel Elements. One is a complete fuel element (element E05-05) which is fully intact except for some small coring taken on the fuel sleeve. Element E05-05 contains about 260 grams of U-235. This element, which is 12-feet long, is contained in a 13-foot long fuel can and is lying horizontally in the FECF. The fuel can, based on information from drawings, is constructed of aluminum alloy 6061, and has an OD of 4.75" and .065" wall thickness.

A second fuel element (element C05-05) was disassembled for examination and only partial compacts, which contain a total of about 225 grams of U-235, are contained in a 3' 5" can (same material and diametrical dimensions as the longer can) stored in a rack in the FECF. This element and element E05-05 were removed from the Peach Bottom Reactor core after 168 equivalent full power days of operation. Upon removal from the core, element C05-05 was determined to have a circumferential crack in the sleeve. The sleeve fracture was determined to be from radial growth in some of the fuel compacts.

The conceptual fuel-handling plan for the two Peach Bottom elements is to section the intact element, and repackage the elements into four overpack cans in the FECF for placement into

the IFSF.

1.4.2 Core 2

Core 2 operated close to its full design lifetime of 900 equivalent full-power days (EFPD). The design of a new coated fuel particle resolved the problem experienced in Core 1, and all elements were in good condition after removal from the reactor. The fuel elements were canned and shipped to the INEEL. Upon receipt, the elements were removed from the cans and 18" of the reflector removed so that the elements would fit into the IFSF storage locations. Up to twelve bare elements are stored in each IFSF storage canister. The IFSF consists of a carbon steel storage rack into which 18" in diameter 11 feet long carbon steel canisters are placed. The carbon steel canisters have lids with lifting bails that reduce air exchange and particulate leakage. The IFSF is a vented and filtered fuel storage facility. There is no attempt to condition the atmosphere either before it enters from outside the facility or once it is inside the storage area. Therefore, the humidity is only regulated by the external and internal environments of the facility and storage canisters.

External visual examinations of the IFSF canisters in FY 1997 revealed no pertinent corrosion on the exterior of any IFSF canisters currently holding the Core 2 elements. No internal inspections of the storage canisters or fuel elements have occurred since the elements were placed into storage. The current assumption at the INTEC concerning the storage facility and canisters is that little to no corrosion will exist since the fuels were received dry (they were never wet during reactor service) and have been stored dry since the time of receipt.

1.5 Radionuclide Inventory

Radionuclide inventory has been estimated based on information contained in references provided in Section J, Attachment J-L. One radionuclide estimate is presented below in Tables 1-10 and 1-11. A second estimate is presented in Engineering Design File 3084. Core 1 was irradiated to 451 EFPD, and Core 2 to 897 EFPD, as compared with the design core lifetime of the fuel of 900 EFPD. The heavy-metal content of each fuel element has been calculated. The sums of all the calculated amounts for the 819 fuel elements irradiated in Core 1 and the 820 elements discharged as Core 2 are presented in Table 1-7, even though only 813 and 787 elements are presently located at the INEEL. The postirradiation uranium loadings for each of the Cores 1 and 2 fuel assembly packages are discussed in Tables 1-8 and 1-9, respectively. The radionuclide content of a typical Peach Bottom Core 2 spent fuel element with a fuel burnup of 73,000 MWd/MTIHM and a cooling time of 120 days is presented in Tables 1-10 and 1-11. The Core 2 data presented in Tables 10 and 11 envelope the Core 1 data. The radionuclide contents shown are given in a safety analysis report on the INEEL irradiated fuels storage facility and are based on 2.5 years of reactor operation at 114 MW(t). Using the radionuclide contents at a cooling time of 120 days as input, a series of calculations was made by means of the ORIGEN-2 code to determine the radioactivity (curies) and thermal power (watts) per fuel element at total decay times of 120 days to one million years. The initial cooling period of 120 days was included in the total decay time. The present heat generation rate is estimated to be 3.7 watts/assembly. Radiation levels from the fuel canisters is expected to be in the several rem/hour range. The source of the radiation

is a combination of the residual fission and activation products, as well as Tl-208, a decay product from the uranium-232 in the fuel meat.

Table 1-7. Postirradiation heavy metal loadings

Nuclide	Mass per core, kg	
	Core 1	Core 2
Th-232	1,439.31	1,172.54
U-232	0.0015	0.0075
U-233	20.52	25.95
U-234	2.96	4.55
U-235	156.52	66.96
U-236	14.27	21.12
U-238	12.32	9.25
Pu-239	0.411	0.2
Pu-240	0.083	0.069
Pu-241	0.063	0.112
Pu-242	0.008	0.054
Np-237		1.625
Total U	206.59	127.83
Uranium assays		
U-235, wt %	75.76	52.38
U-233, wt %	9.94	20.30
U-232, ppm	7.08	58.55

Table 1-8. Peach Bottom Unit I - Core 1 summary of postirradiation uranium loadings by fuel assembly package

Package Type	No. Of Elements	Total U Average (g) Maximum (g)	U-232 Average (ug) Max. (ug)	U-233 average (g) Maximum(g)	U-234 Average (g) Maximum (g)	U-235 average (g) Maximum (g)	U-236 average (g) Maximum (g)	U-238 average (g) Maximum (g)
1	528	268.68 303.81	1645 2081	23.99 27.10	3.71 3.89	206.46 268.84	18.46 20.76	16.06 17.10
2	58	267.46 283.83	1697 2081	24.39 27.10	3.73 3.89	204.46 226.93	18.94 20.76	16.04 16.27
3	7	279.24 287.79	983 960	17.94 19.04	3.47 3.49	227.35 230.81	14.08 14.52	16.39 16.50
4	1	256.77 256.77	1594 1594	20.42 20.42	3.71 3.71	197.31 197.31	19.06 19.06	16.27 16.27
5	1	290.85 290.85	820 820	18.24 18.24	3.44 3.44	229.11 229.11	13.75 13.75	16.31 16.31
6	1	255.9 255.9	1699 1699	21.36 21.36	3.75 3.75	194.85 194.85	19.62 19.62	16.21 16.21
7	1	278.49 278.49	1191 1191	22.71 22.71	3.53 3.53	219.96 219.96	16.25 16.25	16.14 16.14
8	1	297.20 297.20	285 285	11.00 11.00	3.36 3.36	257.31 257.31	8.60 8.60	16.93 16.93
9	71	269.79 295.62	1594 2050	23.67 27.04	3.68 3.96	208.20 258.37	18.15 20.33	16.08 16.71
10	8	268.25 274.76	1836 2050	25.70 27.04	3.77 3.86	203.54 213.19	19.27 20.33	15.96 16.05
11	1	272.57 272.57	1646 1646	25.21 25.21	3.69 3.69	209.35 209.35	18.31 18.31	16.00 16.00
12	1	274.64 274.64	1498 1498	24.36 24.36	3.63 3.63	212.99 212.99	17.61 17.61	16.05 16.05
13	1	285.85 285.85	749 749	17.82 17.82	3.42 3.42	235.34 235.34	12.87 12.87	16.40 16.40
14	98	150.41 155.48	3009 3262	34.81 36.28	3.19 3.34	91.69 96.02	11.90 17.33	8.81 8.86
15	5	268.15 277.75	1715 2013	24.53 25.57	3.73 3.84	205.07 218.51	19.79 20.25	16.03 16.13
16	1	298.17 288.17	651 651	16.82 16.82	3.40 3.40	239.07 239.07	12.35 12.35	16.53 16.53
17	1	277.75 277.75	1279 1279	23.04 23.04	3.55 3.55	218.51 218.51	16.51 16.51	16.13 16.13
18	18	270.69 283.63	1550 2013	23.62 25.61	3.66 3.84	209.37 226.63	17.95 20.25	16.09 16.24
19	3	277.57 278.54	1228 1297	22.79 23.00	3.54 3.57	219.63 219.94	16.46 16.90	16.14 16.14
20	3	268.61 284.63	1378 1559	21.33 22.54	3.61 3.68	210.09 227.42	17.35 18.55	16.23 16.26
21	4	150.60 155.48	2933 3240	34.56 36.17	3.16 3.18	92.24 96.02	11.81 11.96	8.82 8.83

Table 1-9. Peach Bottom Unit I - Core 2 summary of postirradiation uranium loadings by fuel assembly package

Heavy Metal (g)	Types 1, 2, and 3	Type 4
U-233		
Average	33.0	37.8
Maximum	35.2	39.1
U-235		
Average	90.0	36.0
Maximum	189.0	108.4
U-total		
Average	167.0	105.0
Maximum	228.7	108.4
Thorium	1310	2524
Pu-239	0.27	0.08
Pu-240	0.09	0.03
Pu-241	0.15	0.05
Pu-242	0.07	0.03
Pu-total	0.59	0.18

Peach Bottom Core 1 has 21 different fuel package types (see Table 1-5). Peach Bottom Core 2 has two basic initial uranium and thorium loadings, thus the difference in the appearance between the Post Irradiation tables for Core 1 and Core 2.

(Source: GA Technologies Report, ORNL/Sub/86-22047/2, GA-C18525, "Characterization of Peach Bottom Unit 1 Fuel", October 1986)

**Table 1-10. Radioactivity of Peach Bottom-1 reactor spent fuel based on one fuel element;
burnup is 73,000 MWd/MTIHM (curies per element)**

Actinides and Daughters

	120.0D	1.0Yr	10.0Yr	100.0Yr	1000.0Yr	10.0Ky	100.0Ky	1000.0Ky
TL209	0.000E+00	5.872E-07	8.484E-06	8.707E-05	8.356E-04	5.539E-03	6.294E-03	1.252E-04
PB209	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.868E-02	2.564E-01	2.914E-01	5.795E-03
PB210	0.000E+00	2.764E-13	7.880E-10	4.989E-07	8.303E-05	3.298E-03	2.547E-02	4.272E-03
PB214	0.000E+00	4.08SE-11	8.484E-09	9.01BE-07	8.305E-05	3.299E-03	2.548E-02	4.273E-03
BI210	0.000E+00	2.764E-13	7.881E-10	4.989E-07	8.303E-05	3.29SE-03	2.547E-02	4.272E-03
BI213	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.86SE-02	2.564E-01	2.914E-01	5.795E-03
BI214	0.000E+00	4.08SE-11	8.484E-09	9.018E-07	8.305E-05	3.299E-03	2.548E-02	4.273E-03
Po210	0.000E+00	6.573E-14	7.881E-10	4.989E-07	8.303E-05	3.298E-03	2.547E-02	4.272E-03
Po213	0.000E+00	2.660E-05	3.843E-04	3.944E-03	3.785E-02	2.509E-01	2.851E-01	5.670E-03
Po214	0.000E+00	4.087E-11	8.482E-09	9.016E-07	8.303E-05	3.29SE-03	2.547E-02	4.272E-03
Po218	0.000E+00	4.089E-11	8.486E-09	9.019E-07	8.307E-05	3.300E-03	2.548E-02	4.274E-03
AT217	0.000E+00	2.719E-05	3.92BE-04	4.031E-03	3.86E-02	2.564E-01	2.914E-01	5.795E-03
RN222	0.000E+00	4.089E-11	8.486E-09	9.019E-07	8.307E-05	3.300E-03	2.548E-02	4.274E-03
FR221	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.86E-02	2.564E-01	2.914E-01	5.795E-03
RA225	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.868E-02	2.564E-01	2.914E-01	5.795E-03
RA226	0.000E+00	4.089E-11	8.486E-09	9.019E-07	8.307E-05	3.300E-03	2.548E-02	4.274E-03
AC225	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.868E-02	2.564E-01	2.914E-01	5.795E-03
TH229	0.000E+00	2.719E-05	3.928E-04	4.031E-03	3.86E-02	2.564E-01	2.914E-01	5.795E-03
TH230	0.000E+00	2.811E-07	4.060E-06	4.264E-05	4.427E-04	4.232E-03	2.526E-02	4.270E-03
PA233	2.200E+04	4.045E+01	4.175E-07	1.597E-05	1.066E-04	1.342E-04	1.303E-04	9.737E-05
U233	4.201E-01	4.303E-01	4.303E-01	4.301E-01	4.284E-01	4.119E-01	2.779E-01	5.531E-03
U234	4.651E-02	4.652E-02	4.676E-02	4.835E-02	4.977E-02	4.852E-02	3.760E-02	2.931E-03
U236	0.000E+00	4.572E-10	6.583E-09	6.752E-08	6.459E-07	4.197E-06	6.405E-06	6.237E-06
U237	0.000E+00	4.751E-04	3.080E-04	4.046E-06	6.187E-25	0.000E+00	0.000E+00	0.000E+00
NP237	0.000E+00	2.417E-09	4.175E-07	1.597E-05	1.066E-04	1.342E-04	1.303E-04	9.737E-05
PU238	9.501E+00	9.451E+00	8.802E+00	4.323E+00	3.533E-03	0.000E+00	0.000E+00	0.000E+00
PU239	2.690E-02	2.690E-02	2.690E-02	2.683E-02	2.614E-02	2.017E-02	1.510E-03	8.322E-15
PU240	2.300E-02	2.300E-02	2.298E-02	2.276E-02	2.069E-02	7.967E-03	5.716E-07	0.000E+00
PU241	2.000E+01	1.937E+01	1.256E+01	1.649E-01	2.522E-20	0.000E+00	0.000E+00	0.000E+00
AM241	0.000E+00	2.118E-02	2.460E-01	5.818E-01	1.387E-01	7.482E-08	0.000E+00	0.000E+00
Subtotal	2.203E+04	6.982E+01	2.214E+01	5.631E+00	9.782E-01	2.574E+00	2.903E+00	9.775E-02

Fission Products

	120.0D	1.0Yr	10.0Yr	100.0Yr	1000.0Yr	10.0Ky	100.0Ky	1000.0Ky
KR 85	5.000E+01	4.788E+01	2.676E+01	7.946E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR 89	1.170E+03	4.039E+01	1.023E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR 90	3.931E+02	3.868E+02	3.122E+02	3.666E+01	1.823E-08	0.000E+00	0.000E+00	0.000E+00
Y 90	3.931E+02	3.869E+02	3.123E+02	3.666E+01	1.823E-08	0.000E+00	0.000E+00	0.000E+00
Y 91	1.730E+03	9.468E+01	1.155E-15	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ZR 95	2.100E+03	1.474E+02	5.035E-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NB 95	3.980E+03	3.216E+02	1.118E-13	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NB 95M	0.000E+00	1.093E+00	3.735E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU 103	4.801E+02	6.337E+00	4.083E-25	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RH 103M	4.801E+02	5.713E+00	3.681E-25	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU 106	4.001E+02	2.521E+02	5.174E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RH 106	4.001E+02	2.521E+02	5.174E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 127	2.200E+01	4.531E+00	3.785E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 127M	2.200E+01	4.626E+00	3.864E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 129	3.101E+01	1.281E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 129M	3.100E+01	1.968E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I 129	0.000E+00	1.808E-07	1.819E-07	1.819E-07	1.819E-07	1.819E-07	1.811E-07	1.741E-07
CS 137	6.001E+02	5.908E+02	4.799E+02	5.999E+01	5.583E-08	0.000E+00	0.000E+00	0.000E+00
BA 137M	6.001E+02	5.589E+02	4.540E+02	5.675E+01	5.282E-08	0.000E+00	0.000E+00	0.000E+00
BA 140	1.500E+00	3.039E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA 140	2.000E+00	3.497E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE 141	6.351E+02	3.404E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 143	1.900E+01	6.858E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE 144	5.061E+03	2.783E+03	9.190E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 144	5.061E+03	2.783E+03	9.190E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 144M	0.000E+00	3.340E+01	1.103E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM 147	1.500E+03	1.256E+03	1.165E+02	5.486E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SM 147	0.000E+00	5.979E-09	3.392E-08	3.678E-08	3.678E-08	3.67SE-08	3.678E-08	3.67SE-08
SM 151	1.300E+01	1.293E+01	1.207E+01	6.034E+00	5.890E-03	0.000E+00	0.000E+00	0.000E+00
Subtotal	2.518E+04	9.974E+03	1.717E+03	1.962E+02	5.890E-03	2.186E-07	2.179E-07	2.109E-07

**Table 1-11. Decay heat of Peach Bottom-1 reactor spent fuel based on one fuel element;
burnup is 73,000 MWd/MTIHM (watts per element)****Actinides and Daughters**

	120.0D	1.0Yr	10.0Yr	100.0Yr	1000.0Yr	10.0Ky	100.0Ky	1000.0Ky
TL209	0.000E+00	9.757E-09	1.410E-07	1."7E-06	1.388E-05	9.203E-05	1.046E-04	2.080E-06
PB209	0.000E+00	3.126E-08	4.517E-07	4.635E-06	4.449E-05	2.949E-04	3.351E-04	6.664E-06
PB210	0.000E+00	6.404E-17	1.825E-13	1.156E-10	1.923E-08	7.641E-07	5.901E-06	9.897E-07
P8214	0.000E+00	1.304E-13	2.706E-11	2.876E-09	2.649E-07	1.052E-05	8.125E-05	1.363E-05
Bi210	0.000E+00	6.374E-16	1.817E-12	1.150E-09	1.915E-07	7.605E-06	5.874E-05	9.851E-06
Bi211	0.000E+00	3.572E-20	9.967E-17	6.212E-14	1.099E-11	9.483E-10	2.573E-08	3.666E-08
Bi213	0.000E+00	1.143E-07	1.651E-06	1.695E-05	1.626E-04	1.078E-03	1.225E-03	2.436E-05
Bi214	0.000E+00	5.239E-13	1.087E-10	1.156E-08	1.064E-06	4.228E-05	3.265E-04	5.476E-05
PO210	0.000E+00	2.107E-15	2.526E-11	1.599E-08	2.662E-06	1.057E-04	8.166E-04	1.370E-04
PO213	0.000E+00	1.346E-06	1.945E-05	1.996E-04	1.915E-03	1.270E-02	1.443E-02	2.869E-04
PO214	0.000E+00	1.898E-12	3.938E-10	4.186E-08	3.855E-06	1.531E-04	1.183E-03	1.984E-04
PO218	0.000E+00	1.482E-12	3.075E-10	3.26BE-08	3.010E-06	1.196E-04	9.234E-04	1.549E-04
AT217	0.000E+00	1.160E-06	1.676E-05	1.720E-04	1.651E-03	1.094E-02	1.243E-02	2.473E-04
RN222	0.000E+00	1.355E-12	2.812E-10	2.989E-08	2.752E-06	1.093E-04	8.444E-04	1.416E-04
FR221	0.000E+00	1.049E-06	1.516E-05	1.556E-04	1.493E-03	9.897E-03	1.125E-02	2.237E-04
RA225	0.000E+00	1.906E-08	2.754E-07	2.827E-06	2.713E-05	1.798E-04	2.043E-04	4.064E-06
RA226	0.000E+00	1.181E-12	2.450E-10	2.604E-08	2.398E-06	9.527E-05	7.358E-04	1.234E-04
AC225	0.000E+00	9.496E-07	1.372E-05	1.408E-04	1.351E-03	8.958E-03	1.01SE-02	2.024E-04
TH229	0.000E+00	8.317E-07	1.202E-05	1.233E-04	1.183E-03	7.845E-03	8.914E-03	1.773E-04
TH230	0.000E+00	7.956E-09	1.149E-07	1.207E-06	1.253E-05	1.198E-04	7.147E-04	1.208E-04
PA233	4.994E+01	9.182E-02	9.477E-10	3.625E-08	2.418E-07	3.046E-07	2.958E-07	2.210E-07
U233	1.221E-02	1.251E-02	1.251E-02	1.250E-02	1.245E-02	1.197E-02	8.079E-03	1.608E-04
U234	1.340E-03	1.340E-03	1.347E-03	1.393E-03	1.434E-03	1.398E-03	1.083E-03	8.443E-05
U235	0.000E+00	4.659E-13	6.710E-12	6.906E-11	6.83BE-10	6.029E-09	2.274E-08	2.407E-08
U236	0.000E+00	1.239E-11	1.783E-10	1.829E-09	1.750E-08	1.137E-07	1.735E-07	1.690E-07
NP237	0.000E+00	7.388E-11	1.276E-08	4.881E-07	3.257E-06	4.101E-06	3.983E-06	2.976E-06
PU238	3.149E-01	3.132E-01	2.917E-01	1.433E-01	1.171E-04	1.555E-35	0.000E+00	0.000E+00
PU239	8.291E-D4	8.291E-04	8.289E-04	8.267E-04	8.056E-04	6.216E-04	4.652E-05	2.565E-16
PU240	7.163E-04	7.162E-04	7.155E-04	7.087E-04	6.442E-04	2.481E-04	1.780E-08	0.000E+00
PU241	6.201E-04	6.004E-04	3.893E-04	5.113E-06	7.819E-25	0.000E+00	0.000E+00	0.000E+00
AM241	0.000E+00	7.036E-04	8.171E-03	1.933E-02	4.608E-03	2.485E-09	0.000E+00	0.000E+00
Subtotal	5.027E+01	4.217E-01	3.158E-01	1.789E-01	2.794E-02	6.699E-02	7.397E-02	2.379E-03

Fission Products

	120.0D	1.0Yr	10.0Yr	100.0Yr	1000.0Yr	10.0Ky	100.0Ky	1000.0Ky
KR 85	7.490E-02	7.172E-02	4.008E-02	1.190E-04	6.370E-30	0.000E+00	0.000E+00	0.000E+00
SR 89	4.045E+00	1.396E-01	3.537E-21	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR 90	4.562E-01	4.490E-01	3.624E-01	4.254E-02	2.116E-11	0.000E+00	0.000E+00	0.000E+00
Y 90	2.178E+00	2.144E+00	1.731E+00	2.032E-01	1.011E-10	0.000E+00	0.000E+00	0.000E+00
Y 91	6.214E+00	3.400E-01	4.149E-18	0.000E+00	0.00DE+00	0.000E+00	0.000E+00	0.000E+00
ZR 95	1.064E+01	7.464E-01	2.550E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NB 95	1.909E+01	1.543E+00	5.362E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NB 95M	0.000E+00	1.519E-03	5.190E-19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU 103	1.606E+00	2.120E-02	1.366E-27	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RH 103M	1.105E-01	1.315E-03	8.472E-29	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RU 106	2.379E-02	1.499E-02	3.076E-05	4.070E-32	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RH 106	3.837E+00	2.418E+00	4.962E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 127	2.971E-02	6.118E-03	5.111E-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 127H	1.184E-02	2.488E-03	2.07BE-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 129	1.108E-01	4.578E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE 129M	5.436E-02	3.451E-04	1.220E-33	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I 129	0.000E+00	8.363E-11	8.416E-11	8.416E-11	8.416E-11	8.413E-11	8.379E-11	8.053E-11
CS 137	6.638E-01	6.535E-01	5.308E-01	6.635E-02	6.175E-11	0.000E+00	0.000E+00	0.000E+00
BA 137H	2.356E+00	2.195E+00	1.783E+00	2.228E-01	2.074E-10	0.000E+00	0.000E+00	0.000E+00
BA 140	5.023E-03	8.479E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA 140	3.353E-02	5.863E-08	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE 141	9.29SE-01	4.984E-03	1.821E-33	0.00GE+00	0.000E+00	0.000E+00	0.00GE+00	0.000E+00
PR 143	3.540E-02	1.27SE-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.0G0E+00
CE 144	3.357E+00	1.846E+00	6.096E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 144	3.720E+01	2.046E+01	6.755E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR 144M	0.000E+00	1.143E-02	3.773E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM 147	5.381E-01	4.506E-01	4.179E-02	1.968E-12	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SM 147	0.000E+00	8.187E-11	4.645E-10	5.036E-10	5.036E-10	5.036E-10	5.036E-10	5.036E-10
SM 151	1.524E-03	1.517E-03	1.415E-03	7.075E-04	6.906E-07	5.423E-37	0.000E+00	0.000E+00
Subtotal	9.360E+01	3.352E+01	4.502E+00	5.357E-01	6.916E-07	5.877E-10	5.874E-10	5.841E-10

2.0 SHIPPINGPORT LWBR

2.1 Introduction

This report summarizes the pertinent information for the fuel used in the Shippingport Light Water Breeder Reactor (LWBR) core installed into the Shippingport reactor vessel. To date, the Shippingport fuel has been identified in a variety of different ways (see Table 2-1).

Table 2-1. Shippingport Designations and Definitions

Name Used	Definition
Shippingport	Shippingport reactor
Shippingport PWR	Shippingport Pressurized Water Reactor
Shippingport PWR-C1 or -C2	Shippingport PWR-Core 1 or Core 2
Shippingport PWR-C1-S1 or -S2 or...	Shippingport PWR-Core 1- Seed 1 or Seed 2 or...
Shippingport LWBR	Shippingport Light Water Breeder Reactor (same Rx, different core and design)

The Shippingport Atomic Power Station, located on the south bank of the Ohio River in Shippingport Borough, Beaver County Pennsylvania, was the first large-scale, central station application of nuclear power for civilian use in the United States. The station was jointly owned by U.S. DOE and the Duquesne Light Company, which operated the reactor since its initial startup in December 1957 and final shut down in 1983. During this operating period two pressurized water reactor (PWR) cores and one Light Water Breeder Reactor (LWBR) core saw service. PWR Core 1 operated until February 1964, having been partially refueled three times (4 different Seed cores used). Following plant modifications, Core 2 was installed and began power operation in May 1965. Core 2 underwent one partial refueling in 1969 (2 different Seed cores used), and continued in operation until February 1974 when the plant was shut down for repair of the turbine generator. At that time preparations began for refueling with the LWBR core, which began power operation in calendar year 1978 and operated until 1983.

All cores (including the seed and blanket assemblies from the two PWR cores) were sent to the Navy's Expended Core Facility (ECF) in Idaho for analysis. After analysis at the ECF the remaining fuel rods, assemblies, and scrap were sent to the INEEL or Hanford depending upon the type of material. Generally, the INEEL received the seed assemblies from the PWR reactors and the entire LWBR core, while Hanford received the blanket assemblies from the two PWR cores.

After the Shippingport PWR program was completed in 1974, work was begun to modify the Shippingport reactor vessel to accommodate a completely different type of core; a Light Water Breeder Reactor (LWBR). This new LWBR used an ^{233}U -Thorium fuel cycle that required a completely redesigned fuel form from the PWR fuel types. After appropriate modifications were made to the vessel to accommodate these different fuel forms, the LWBR reactor began operation in 1978 and operated to 1983 when the entire facility was shutdown permanently. The entire core was de-fueled, sent to the Navy's Expended Core Facility (ECF) in Idaho for analysis, and subsequently dried and shipped to the INTEC for

extended storage.

2.2 Physical Description of Fuel

The Shippingport LWBR core was designed to simulate the interior of a large LWBR core environment and to permit net breeding in the entire core. To maximize the ^{232}Th conversion to ^{233}U and minimize the neutron loss to surrounding water, a unique "Seed and Blanket" concept was designed; the seed assembly was inserted into the middle of an annular blanket assembly. The core held twelve of these fuel "modules" (they were designed in a hexagonal shape) which contained a central movable seed region surrounded by a stationary blanket region. These twelve fuel modules were, in turn, surrounded by 15 reflector modules and finally by a stainless steel fill material (required due to the physical constraints of placing a hexagonal shaped core into a circular vessel) (Figures 2-1A and 2-1B). Some of the physical attributes of the LWBR fuel modules are described in Table 2-2.

Table 2-2. Shippingport LWBR Fuel Description

LWBR Core	Seed Module	Blanket Type I	Blanket Type II	Blanket Type III	Reflectors Type IV & V
Fuel Meat	$^{233}\text{UO}_2\text{-ThO}_2$	$^{233}\text{UO}_2\text{-ThO}_2$	$^{233}\text{UO}_2\text{-ThO}_2$	$^{233}\text{UO}_2\text{-ThO}_2$	ThO_2
Fuel Meat Form	Ceramic pellet	Ceramic pellet	Ceramic pellet	Ceramic pellet	Ceramic pellet
Cladding	Zircaloy-4	Zircaloy-4	Zircaloy-4	Zircaloy-4	Zircaloy-4
Dimensions	See Figures 2-4, & 2-6 through 2-8	See Figures 2-4, & 2-6 through 2-8	See Figures 2-4, & 2-6 through 2-8	See Figures 2-4, & 2-6 through 2-8	See Figures 2-4, & 2-6 through 2-8
Enrichment	4.3 - 5.2 wt %	1.2 - 2.0 wt %	1.6 - 2.8 wt %	1.6 - 2.8 wt %	None
No. Of Elements	12	3	3	6	9 & 6 (IV & V)

2.2.1 Fuel Module Design

Of the 12 fuel modules used in the LWBR core there were three central fuel modules (identical and symmetrical to each other) and nine outer modules (not identical or symmetrical) surrounding these central modules. Each fuel module contained a central, axially movable, hexagonal seed and a stationary, annular hexagonal blanket (see Figure 2-2). The three central modules possessed standard blankets while the outer nine modules had power-flattening blanket configurations which used a larger outer blanket region that was fueled with a slightly higher uranium-233 content than the blanket regions of the inner modules. Use of this more highly loaded blanket region produced a relatively uniform power distribution within the interior of the core, thereby better simulating the breeding environment of a large (1000 MW(e)) core (see section 2.2.3).

In the seed and blanket regions, the fuel pellets contain a solid state solution of uranium-233

and thorium; both in oxide form; urania (UO_2) and thoria (ThO_2). In the seed region, the uranium-233 loading is about 5 to 6 weight percent (wt %) of uranium oxide in the thoria. In the blanket, the uranium-233 loading is about 1.2 to 3 wt % uranium oxide. In the reflector region and in short regions at the top and bottom of the seed and blanket, the pellets contain only thorium yielding both a radial and an axial blanket, respectively. In all of the fuel regions of the core the ceramic pellets are nominally 97 percent of their maximum achievable theoretical density.

LWBR used a variety of rods in the construction of the various module types used in the core. The rods were fabricated by stacking different numbers and variations of $^{233}\text{UO}_2$ - ThO_2 binary and/or ThO_2 ceramic pellets into individual Zircaloy-4 tubes. By using different rods in the fabrication of the various module types, the neutron flux could be specifically altered to both control the reactions of the core and minimize the loss of neutrons from the core interior (see Variable Geometry Control in the Shippingport LWBR). The types of rods used in the LWBR include standard seed rods, standard blanket rods, Power-Flattening (PF) rods, and reflector rods. The LWBR core contained 17,288 individual rods. The different rod configurations and typical numbers of rods in the specific fuel module types are described in Table 2-3. Further information is contained in references provided in Section J, Attachment J-L.

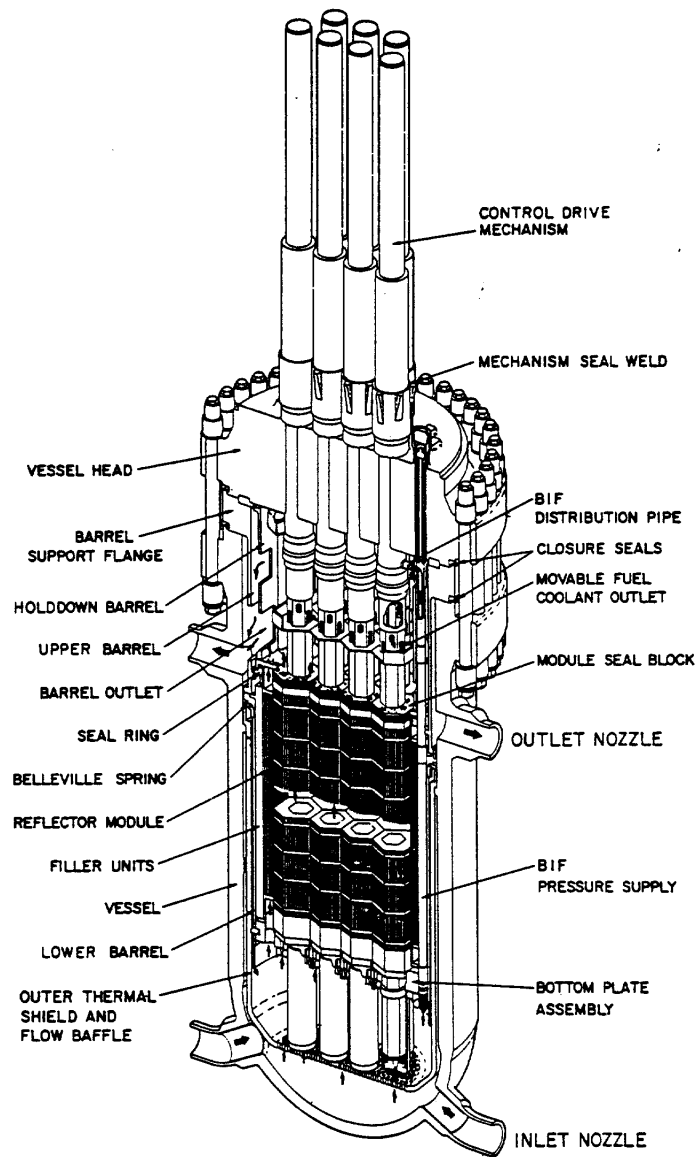


Figure 2-1A. LWBR Core Cutaway View

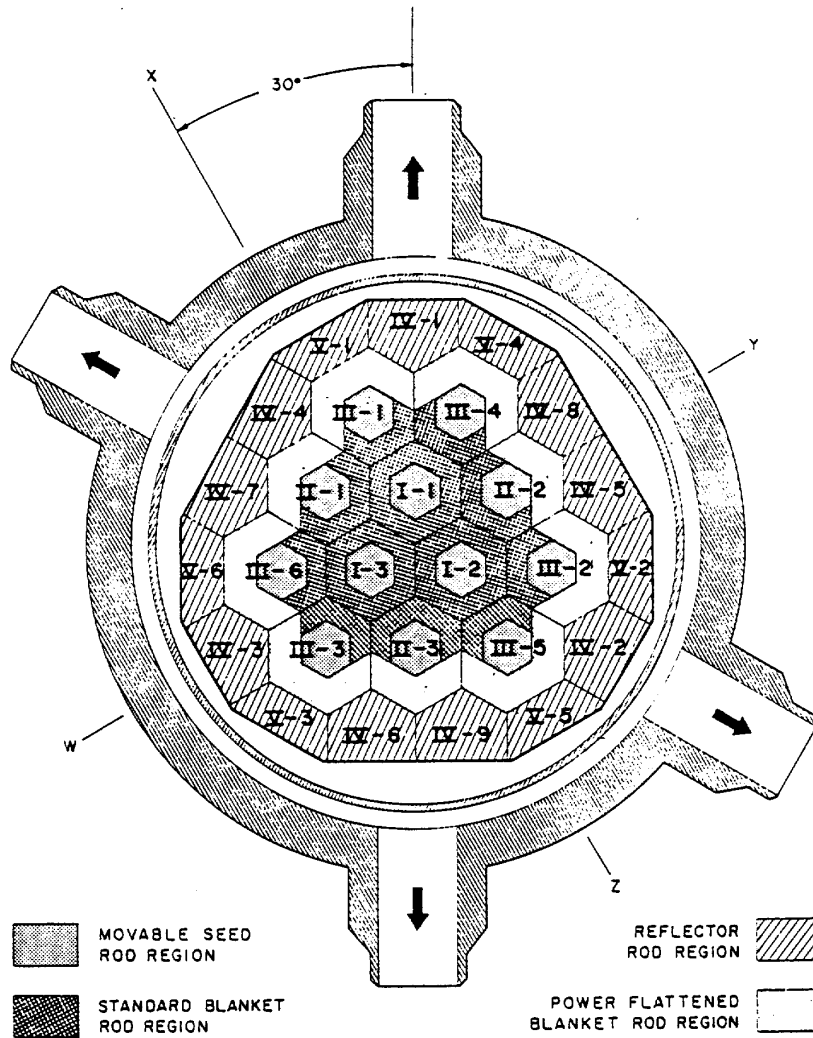
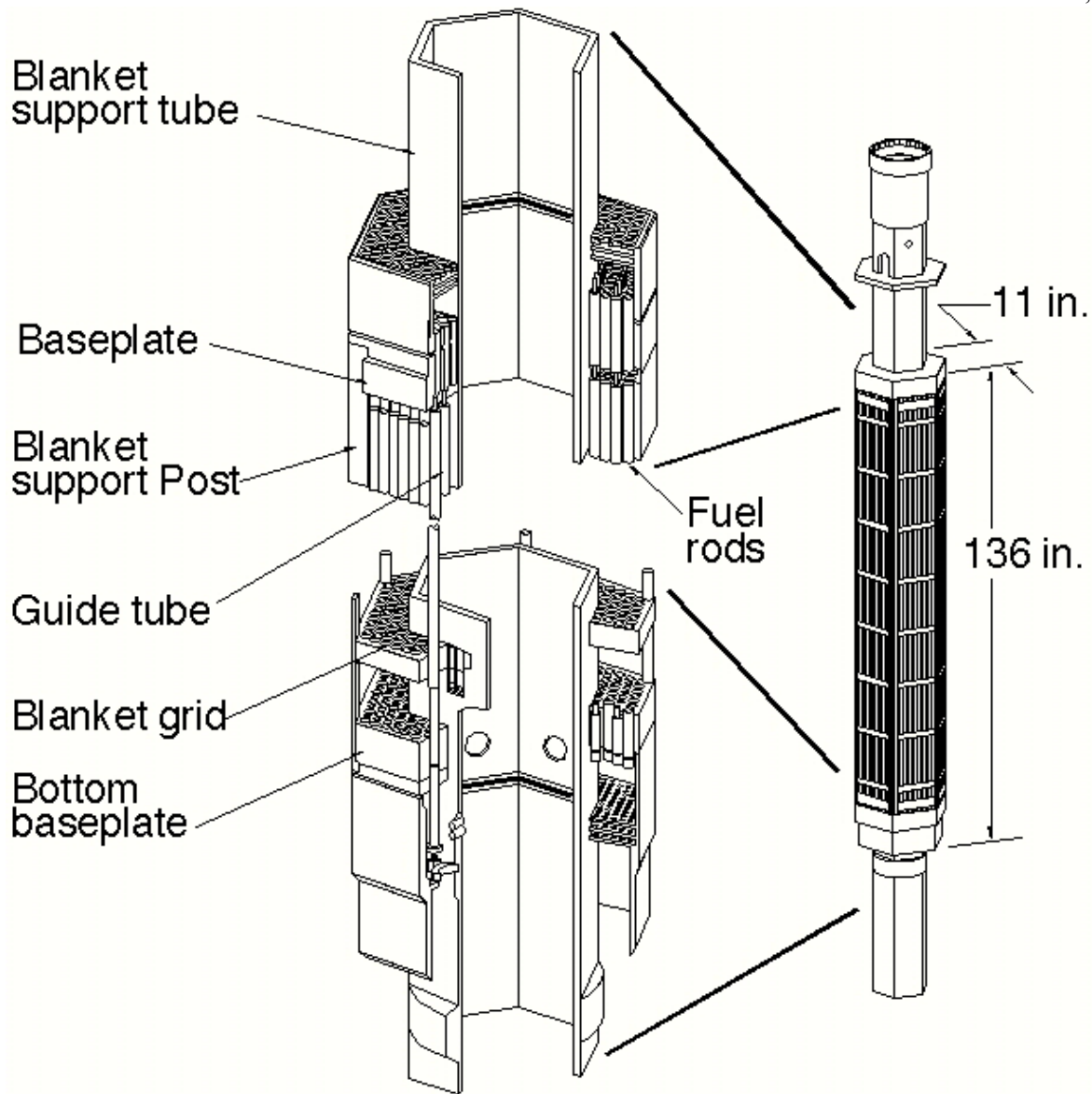


Figure 2-1B. LWBR Core Cross Section View



LWBR Assembly

P96 0366

Figure 2-2. Typical LWBR Assembly (both seed and blanket modules)

Table 2-3. Shippingport LWBR Fuel Rods and Modules

Seed Module	Blanket (Type I)	Blanket (Type II)	Blanket (Type III)	Reflector (Type IV)	Reflector (Type V)
619 seed rods	444 standard rods	261 standard rods	187 standard rods	228 reflector rods	166 reflector rods
0.306" O.D. rods		303 PF rods	446 PF rods		
	0.571" O.D. rods	0.571" O.D. rods	0.571" O.D. rods	0.832" O.D. rods	0.832" O.D. rods
		0.527" O.D. rods	0.527" O.D. rods		
104" long	104" long	104" long	104" long	104" long	104" long
		104" long	104" long		
53,400 MWd/MTU	22,800 MWd/MTU	25,200 MWd/MTU	22,800 MWd/MTU	4,100 MWd/MTU	4,100 MWd/MTU

All the rods used the same basic fuel pellet compositions; $^{233}\text{UO}_2\text{-ThO}_2$ binary, ceramic pellets or ThO_2 ceramic pellets. However, the physical configurations of the two types of pellets contained within the individual rods were varied greatly (see Figures 2-3, 2-5A and 2-5B). Additionally, the physical shapes of the different module types were varied to assist with the power-flattening capabilities of the reactor as well as assisting in physically emplacing the hexagonally shaped modules into the circular shaped reactor vessel (see Figure 2-4). The different types of fuel rods are shown in Figures 2-6 through 2-8.

2.2.2 Reflector Modules Description

Surrounding the 12 hexagonal fuel modules in the LWBR core was an annular region, about 8 inches thick, made up of 15 reflector blanket modules. These modules did not contain uranium-233 fuel initially, but instead contained thorium (ThO_2) pellets in 0.832" O.D. Zircaloy-4 tubes. The purpose of the reflector blanket region was to limit neutron losses from the core to less than about 0.8 percent of all neutrons. Use of this peripheral reflector blanket in the small LWBR Core assured an unambiguous quantitative demonstration of breeding within the entire core. The composition, physical geometry, and rod configuration are included in the above tables.

The difference between Type IV and Type V reflector modules is strictly one of geometry. Two distinct geometries were needed to physically fit the hexagonally shaped modules into the existing circular PWR vessel.

The filler units were composed of a ring of stainless steel slabs whose purpose was to fill up the area between the outside of the reflector blanket and the core barrel to prevent water flow from bypassing the core through this area.

2.2.3 Core Loading and Fuel Distribution

The Shippingport LWBR core utilized the unique concept of placing a movable, central seed module inside a stationary, annular blanket module. This concept provided maximum flexibility for the seed to provide neutrons as efficiently as possible and for the blanket to utilize the neutrons efficiently in producing new fissile fuel by neutron absorption in the

fertile fuel. One of the main results arising out of minimizing neutron losses is the control of core reactivity by varying the spatial relationship between moveable seed fuel assemblies and stationary blanket assemblies rather than by conventional neutron-absorbing poison control rods. The fuel rods were close-packed with a triangular pitch with a rod-to-rod spacing of about 0.060 inches to minimize the water in the core, and give the desired neutron energy spectrum. This is significantly tighter than the packing of rods in commercial fuel.

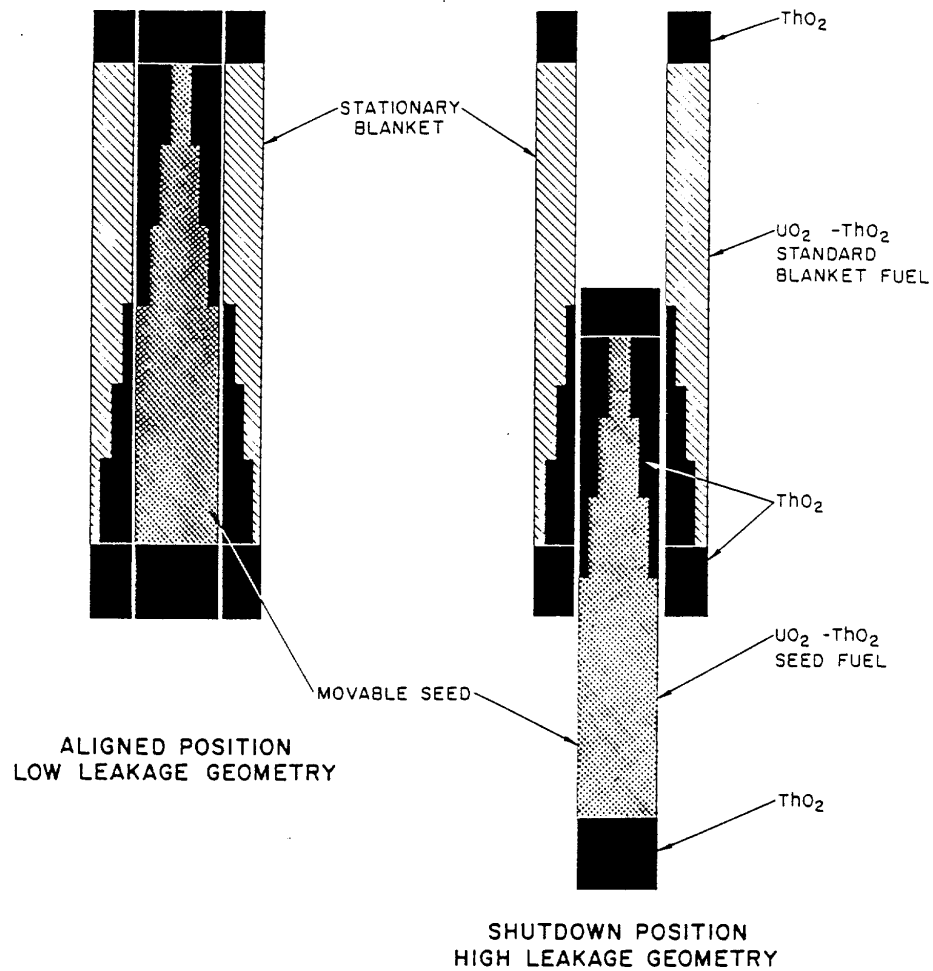


Figure 2-3. Variable Geometry Nuclear Control Concept

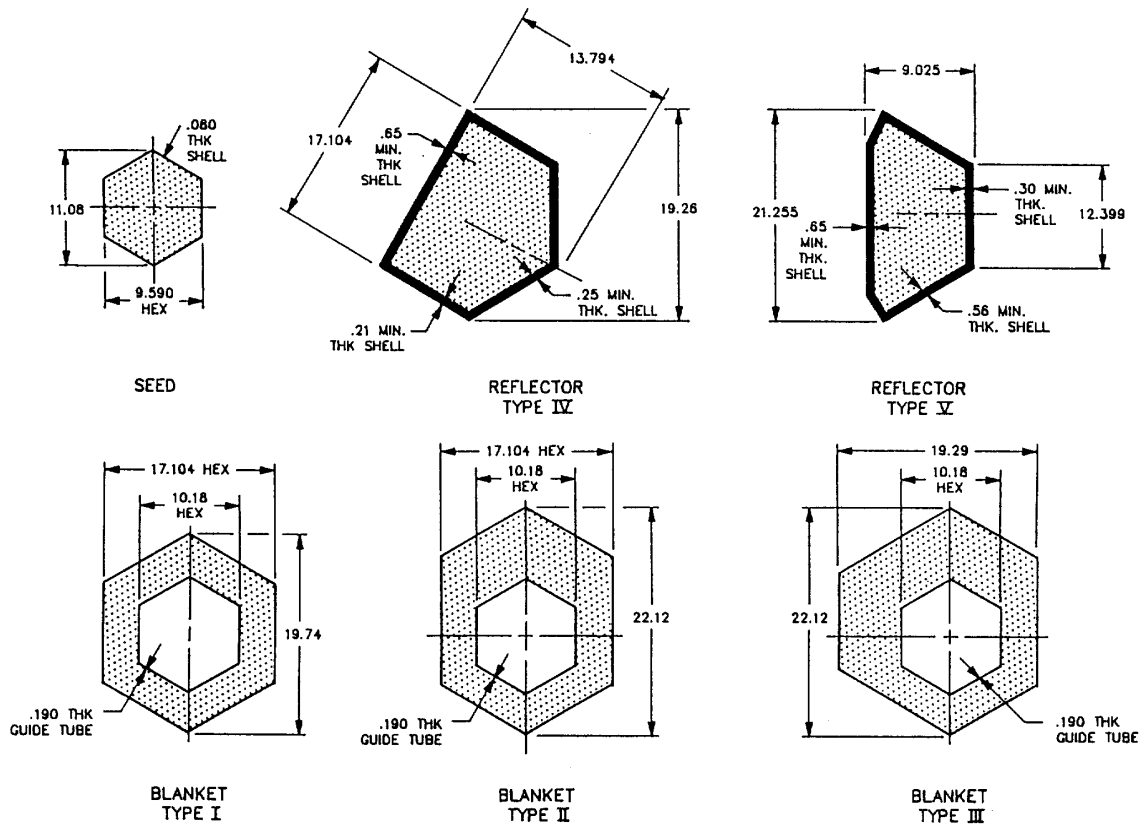


Figure 2-4. LWBR Module Cross Sectional Dimensions

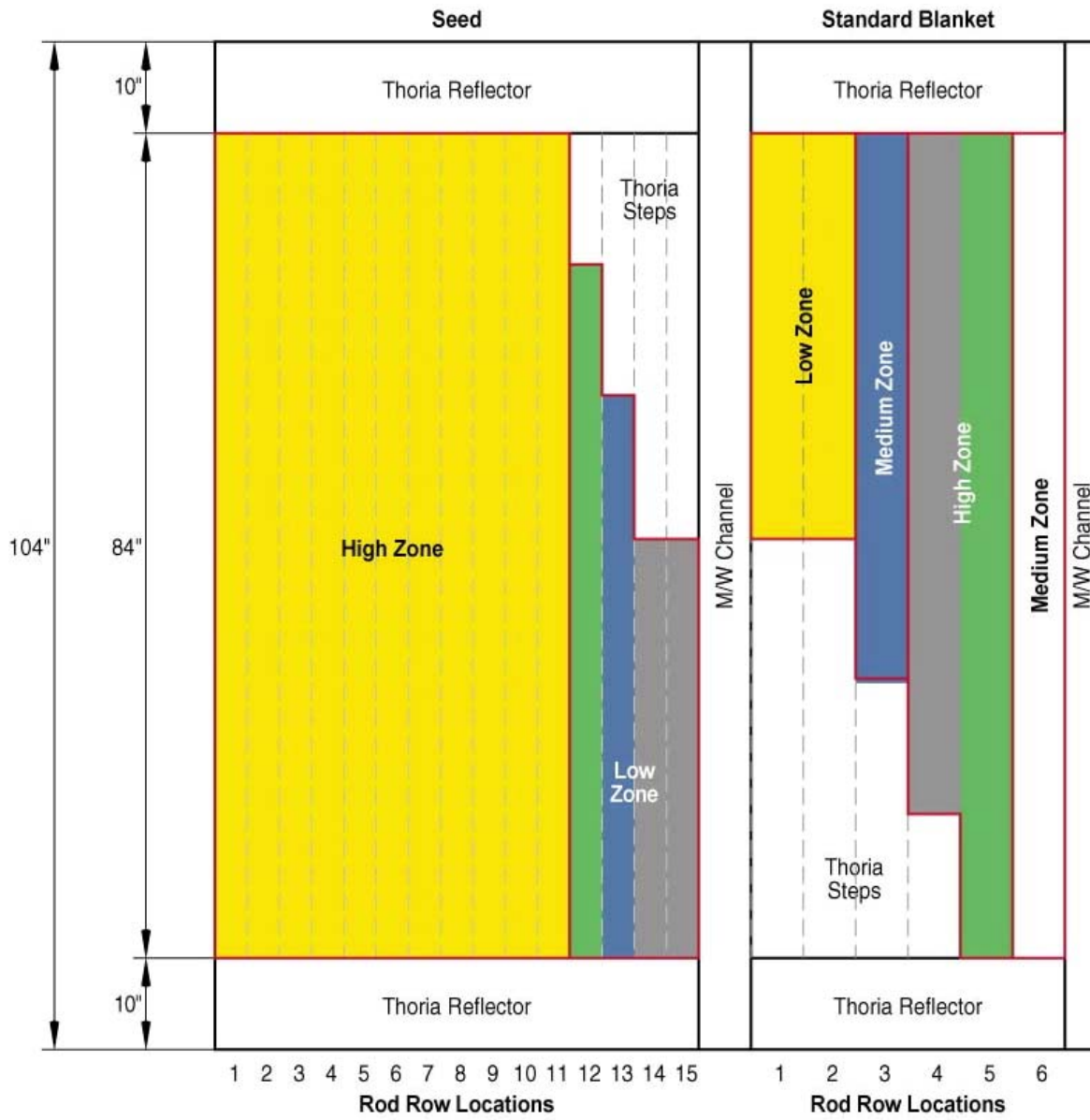
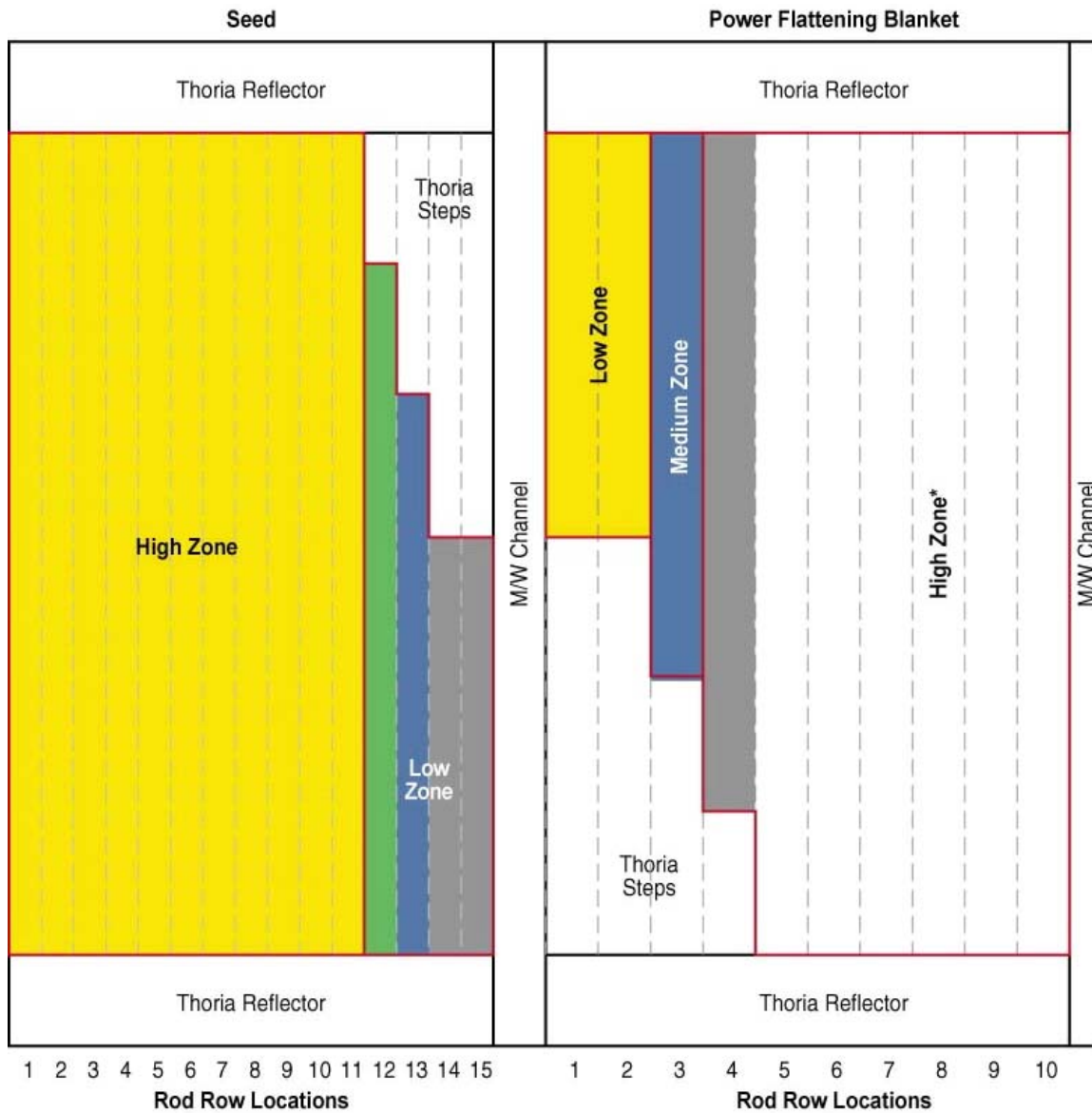


Figure 2-5A. Schematic of LWBR Type I Module Fuel Composition



*Except for eight Medium zone rods per module in row six
 □(4 on each side, along interface between modules).

Figure 2-5B. Schematic of Power Flattening Sides of Type II and Type III Modules

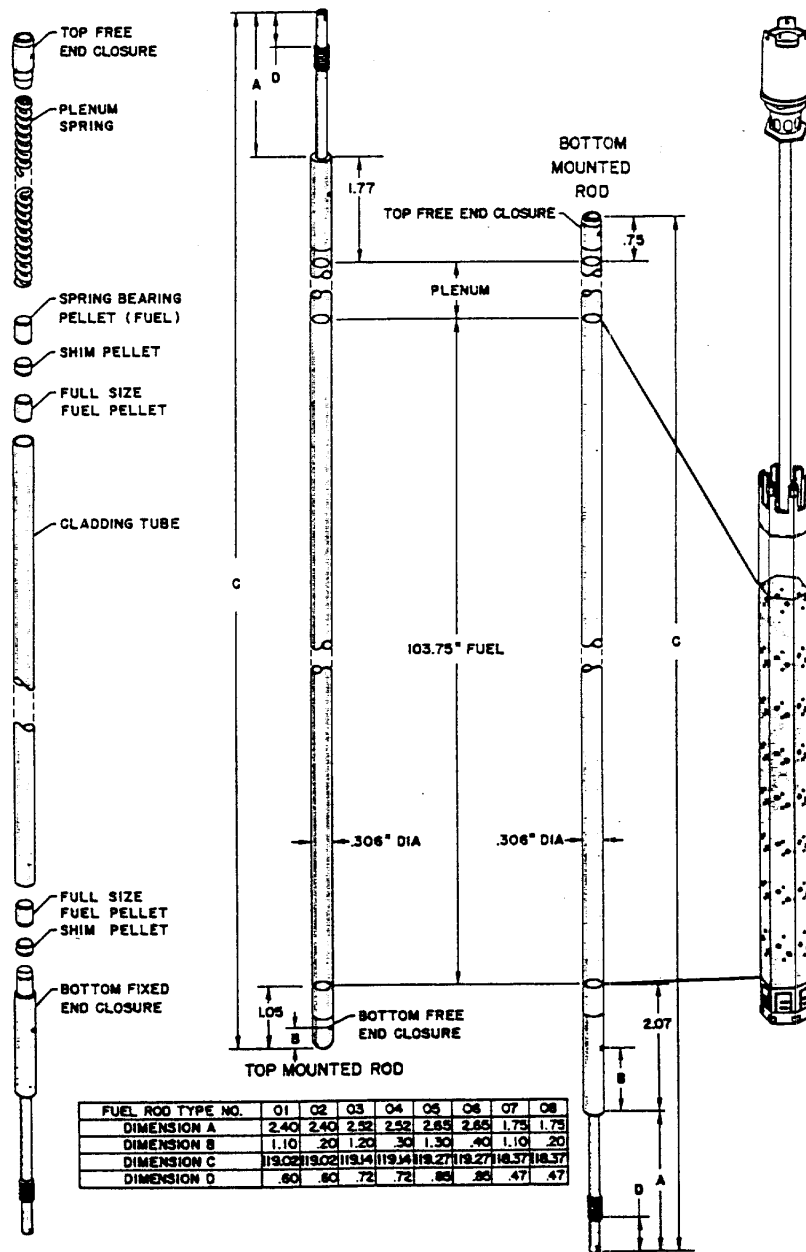


Figure 2-6. Movable Seed Fuel Rods

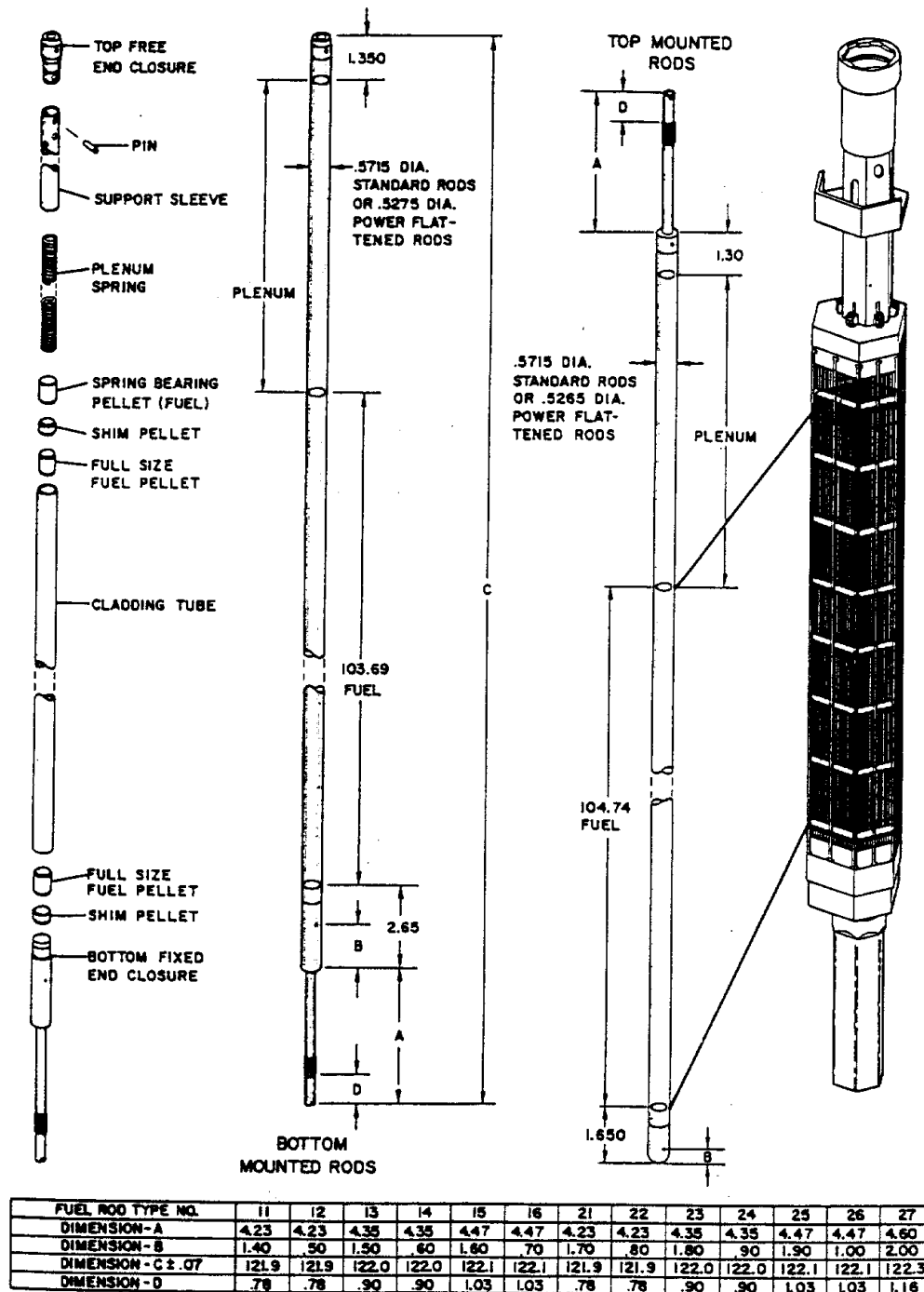


Figure 2-7. Standard Blanket Fuel Rods

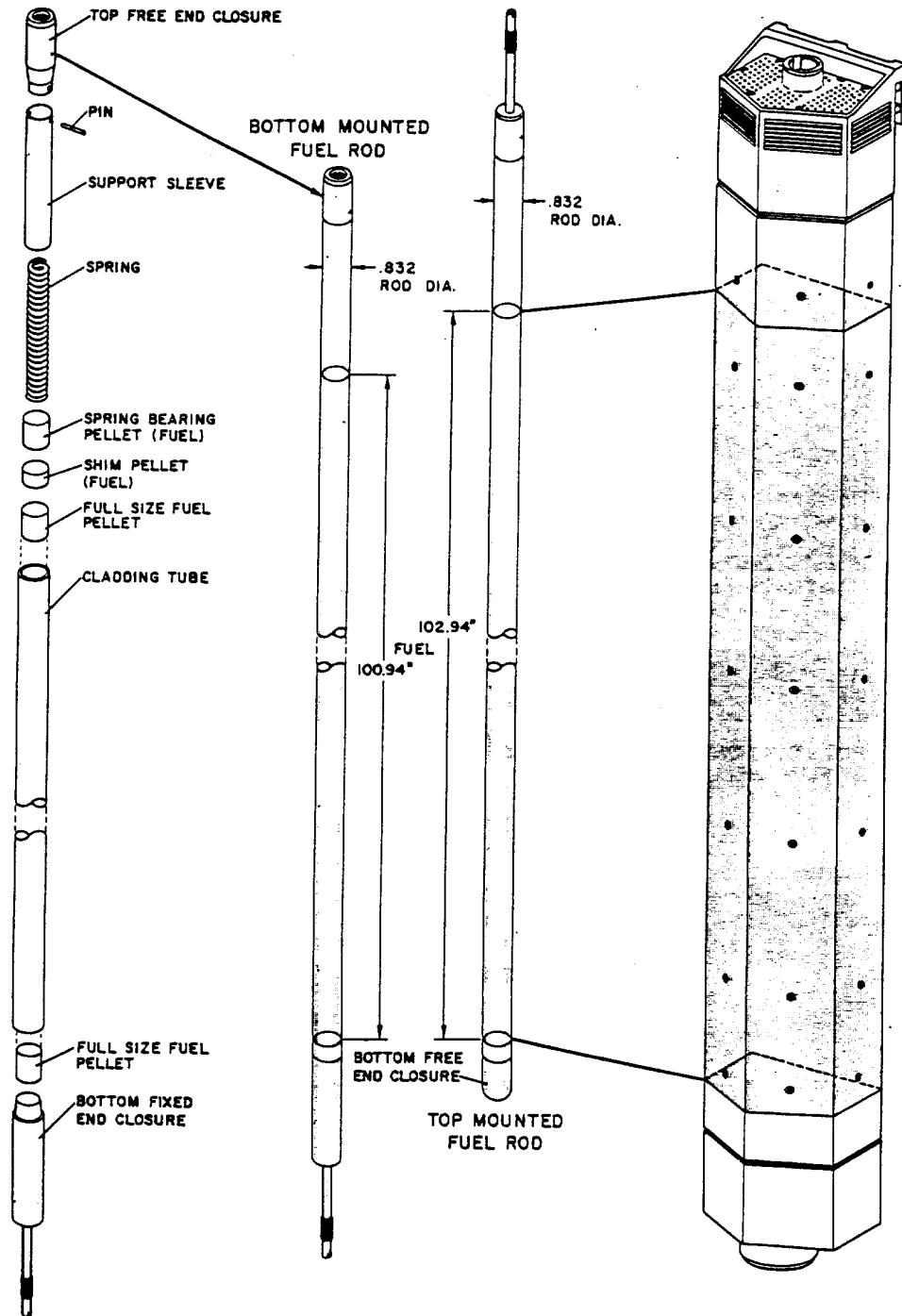


Figure 2-8. Reflector Fuel Rods

To achieve maximum efficiency, the Shippingport LWBR core contained both radial and axial variation of fuel composition (see Figure 2-5). The fuel is approximately 104 inches long, including an axial reflector of 10 inches of ThO₂ on the top and bottom. In the Central Seed Modules, starting at the core center, there are 11 rows of rods that contain high-zone ²³³UO₂-ThO₂ binary pellets in the middle 84 inches of the total length. In the next four rows the fuel rods contained low-zone binary pellets and, coupled with a larger region, ThO₂ pellets at the top end of the rods to produce the stepped arrangement shown in Figure 2-3.

The blanket assembly contains low-, medium-, and high-zone binary pellets and ThO₂ pellets in the rods arranged as shown in Figure 2-3. This combination of radial and axial fuel zones served the purpose of reducing power peaking in the vicinity of the metal and water channels. The stepped arrangement also improved the reactivity worth of the movable fuel seed assembly as it changed elevation.

The rods in the standard (or regular) blanket region of the core have a 0.571" O.D. The Power-Flattening (PF) blanket region contains smaller rods than the standard blanket; 0.527" O.D., but the rods are on the same pitch as in the standard blanket. This gave the PF blanket region a rod spacing of ~100 mils and a lower metal-to-water ratio. This region also had a higher fissile loading than the standard region. This combination of lower metal-to-water ratio and higher fissile loading gave the power flattening blankets a higher reactivity than the standard blanket, which tended to flatten the radial power distribution across the core.

2.2.4 Variable Geometry Control

The LWBR used a variable geometry control concept based on changing the position of the movable seed fuel assembly, relative to the stationary blanket assembly, to achieve the proper neutron balance in the core. Changing the position of the seed assembly relative to the blanket assembly changed the relative amounts of neutron absorptions in the fissile (uranium-233) and fertile (thorium) fuel materials.

The LWBR nuclear design is such that the more highly loaded seed has a k_{∞} greater than one ($k_{\infty} > 1.0$) and the lower loaded blanket has a k_{∞} less than one. Reactivity is controlled by varying the leakage of neutrons from the high k_{∞} seed regions into the low k_{∞} blanket regions. This is achieved by axially positioning the seed section of the core so as to change core geometry rather than by using conventional parasitic neutron-absorbing poisons. With this method of control, which is made practical by the seed-blanket concept, no neutrons are wasted in control rods or soluble poisons. Rather, any excess neutrons are absorbed in fertile thorium material, and good neutron economy is achieved. The reactivity worth of the movable seed is increased by using lengths of natural thoria in some of the seed and blanket rods (see Figure 2-3).

When the reactor was shut down, the seed assemblies were aligned below the rest of the fuel in the core (see Figure 2-3). To start up the reactor, the operator raised the seed assemblies in a uniform bank by remote control. By moving the seed fuel up, more nearly into alignment with the rest of the core, the operator brought the uranium-233 bearing parts of the

fuel closer together increasing the likelihood that some of the excess neutrons would cause fissions in uranium-233 atoms. The movable-fuel control system was designed so that, under any operating condition, when the movable seed fuel assembly was lowered relative to the stationary blanket the reactivity of the core always decreased. This up and down movement of the seed assembly enabled the operator to control the reactor's criticality.

During normal power operation all seeds were aligned as a uniform bank. At the beginning of core life, critical operation occurred with the seeds down about 2 feet lower than the stationary blanket. As the core operated, the seed assemblies were moved gradually upward toward a position about 2 feet higher than the blanket at the end of core life. The operation of the movable fuel control system was similar in many respects to that of the movable poison rod control used in many light water reactors.

2.3 Packaging

Further information on fuel packaging is contained in references provided in Section J, Attachment J-L. After reactor irradiation the fuel was shipped to the Naval Reactors Facility at the INEEL where a Proof of Breeding destructive examination was conducted in the Expanded Core Facility. This program involved the removal of fuel rods from selected assemblies (seed, blanket, and reflector) and a destructive examination of some of the rods. The rods were removed underwater by gripping the ends of the rods and pulling them vertically out of the assembly one at a time. The rod pulling equipment utilized a computer controlled, remote, underwater system with underwater television camera monitoring. After the examination the fuel and pieces were placed into a stainless steel storage canister. Table 2-4 describes the contents of the different types of canisters.

Table 2-4. LWBR Storage Configuration and Condition in Canisters

No.	Canister Type	Description
27	Type A	Canisters containing one intact module (seed, blanket, or reflector) with all fuel rods in place. Also, has permanently attached shipping plates and lift adapter plates.
12	Type B	Contain partially de-rodded fuel modules (modules that have had some rods removed). There are special clamps installed inside the canister to hold these partial modules inside the canister w/o movement. <ul style="list-style-type: none"> • 30 to 100 rods were removed from each module • 2 modules (1 seed and 1 reflector) have the outer shells removed. • 1 module (Blanket III-2) is completely disassembled
4	Type C	Contain the rods removed from the modules stored in Type B canisters. These are: <ul style="list-style-type: none"> • 3 blanket canisters, 381 irradiated rods • 1 reflector canister, 127 irradiated rods A special grid was constructed for each canister that allowed the rods to be individually packed into the canister w/o movement inside the canister.

The storage canisters are constructed of 304 stainless steel. The dimensions are 25.5 inch O.D. by 24.75 inch ID by 158.5 inch outside length. The canister shell is welded to a girth ring, which is 2.5 inches thick and contains the machined cut-out shape for the module that fits inside. The girth ring also contains six 1-inch diameter threaded holes for lifting the

canister during operations before the closure head is bolted to the canister prior to shipment. Guides, which are bolted to the girth ring and extend downward align the module as it is placed in the canister and laterally support the module once it is inside. Sitting on the bottom plate of the canister is a crushable pad with a load spreading plate upon which the module rests. All components are constructed of 304 stainless steel.

The irradiated fuel modules were loaded into the storage canisters underwater and then the closure head of the storage canister was secured by twelve 1-inch diameter bolts and sealed by a resilient all-metallic gasket. The gasket is silver-plated inconel with an O-ring configuration. Each bolt hole is also sealed by a metallic O-ring. All LWBR fuel was dried using approved procedures by the ECF at Idaho using a vacuum drying processes similar to the commercial nuclear fuel utilities before being shipped to the INTEC. The process used a vacuum inside each storage canister/cask to de-water the interior. No external heating or other conditioning methods were applied along with the vacuum process. After the canister was determined to be de-watered it was isolated and the internal pressure was monitored for increased values. The canisters were backfilled with neon gas and leak tested. The fuel was then shipped to the INTEC where it was stored in dry wells at the INTEC (see Figure 2-9).

2.4 As Stored Condition

No external or internal inspections of the LWBR fuel storage canisters have been performed while in storage at the INTEC. Therefore, the actual condition of the canisters and the fuel material stored inside the canisters is unknown. The general assumption for these particular fuel types is that little to no corrosion can or will take place inside and outside of the canister while in storage due to the dry storage environment and the drying process that was applied to the fuels before storage. The dry well temperature and pressure were measured for sometime after receipt and loading of the fuel at INTEC and no abnormal indications were observed.

2.5 Radionuclide Inventory

The calculated radionuclide inventory and estimated decay heat for the various LWBR assembly types is contained in references provided in Section J, Attachment J-L. The DTF and ISFSI facility and equipment design and capability (e.g., for all areas of the facility, such as storage, hot cell, transfer areas, canister closure area, waste management area) shall envelope the source term and mass of the LWBR seed and blanket fuel. Storage tubes originally intended for LWBR fuel shall use 120 watts thermal load as the design basis.

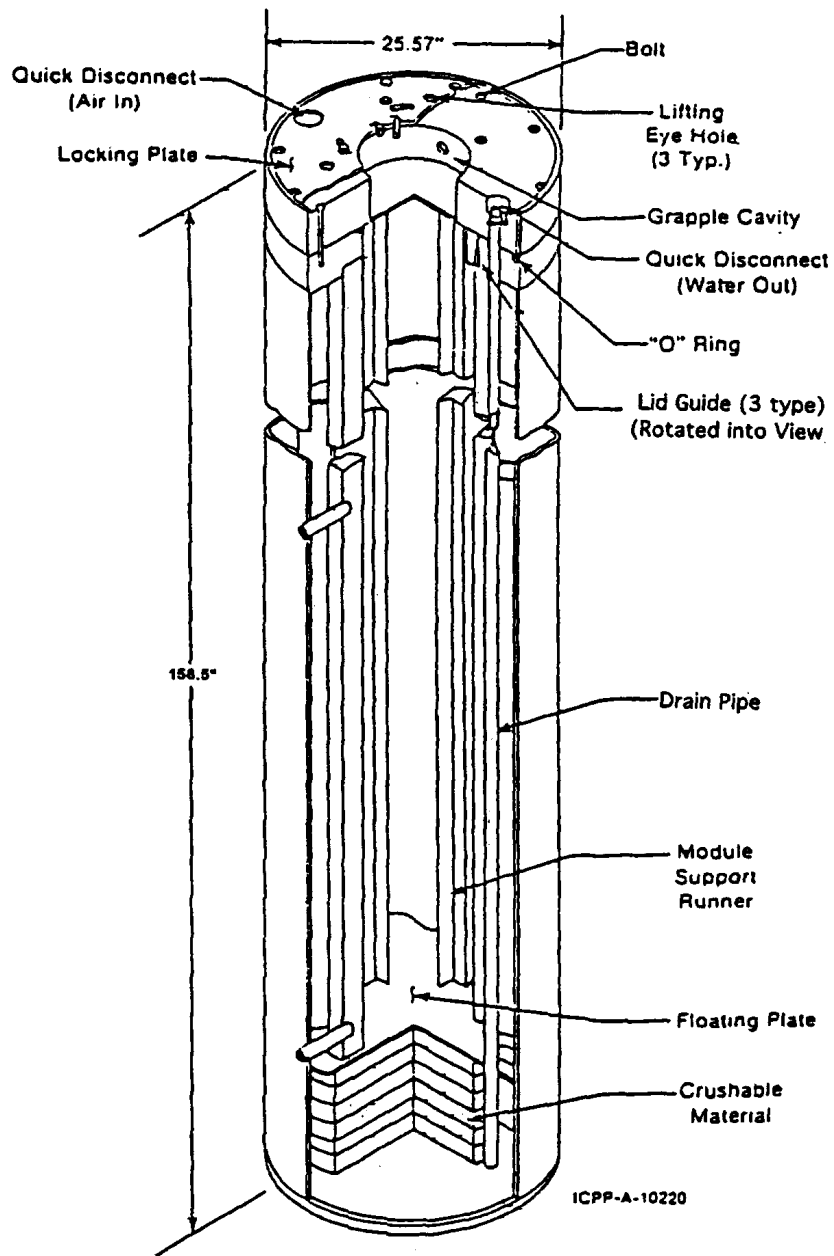


Figure 2-9. Shippingport LWBR Seed Module Storage Canister

**Table 2-5A. Isotopic Activity Concentrations in Curies for a single LWBR
SEED Module (TYPE I).**

Information: Units: CURIES
Burnup: 10269.14 MWd (max)
Burnup: 27749.70 MWd/MTHM
BOL U-233: 16877.36 grams U-233 per module
BOL U-234: 221.64 grams U-234 per module
BOL U-235: 15.46 grams U-235 per module
BOL U-236: 3.44 grams U-236 per module
BOL U-238: 63.57 grams U-238 per module
BOL Th-232: 442731.04 grams Th-232 per module
Fuel Meat: UO₂-ThO₂ (Urania-Thoria)
Fuel Enrichment: 98.23 wt% U-233
Clad: Zircaloy-4

DECAY DATES										
ISOTOPE	01-Jul-96	01-Jul-98	01-Jul-00	01-Jul-02	01-Jul-05	01-Jul-10	01-Jul-15	01-Jul-20	01-Jul-25	01-Jul-30
H 3	7.277E+01	6.504E+01	5.813E+01	5.196E+01	4.391E+01	3.317E+01	2.505E+01	1.892E+01	1.429E+01	1.079E+01
BE 10	2.394E-06	2.394E-06	2.394E-06	2.394E-06	2.394E-06	2.394E-06	2.394E-06	2.394E-06	2.394E-06	2.394E-06
C 14	8.896E-01	8.894E-01	8.892E-01	8.889E-01	8.886E-01	8.881E-01	8.875E-01	8.870E-01	8.865E-01	8.859E-01
CL 36	1.859E-02	1.859E-02	1.859E-02	1.859E-02	1.859E-02	1.859E-02	1.859E-02	1.859E-02	1.859E-02	1.859E-02
CR 51	2.833E-52	3.322E-60	3.799E-68	4.454E-76	5.515E-88	8.007-108	1.162-127	1.646-147	2.389-167	3.469-187
MN 54	4.517E-04	8.947E-05	1.768E-05	3.502E-06	3.080E-07	5.365E-09	9.345E-11	1.624E-12	2.829E-14	4.928E-16
FE 55	6.220E+00	3.651E+00	2.141E+00	1.257E+00	5.648E-01	1.490E-01	3.928E-02	1.035E-02	2.731E-03	7.202E-04
FE 59	2.817E-33	3.685E-38	4.746E-43	6.209E-48	2.892E-55	1.762E-67	1.074E-79	6.444E-92	3.927-104	2.393-116
CO 60	1.385E+02	1.065E+02	8.183E+01	6.291E+01	4.240E+01	2.197E+01	1.138E+01	5.894E+00	3.054E+00	1.582E+00
NI 59	6.359E-02	6.359E-02	6.359E-02	6.359E-02	6.359E-02	6.359E-02	6.358E-02	6.358E-02	6.358E-02	6.358E-02

NI 63	7.988E+00	7.869E+00	7.751E+00	7.635E+00	7.465E+00	7.189E+00	6.923E+00	6.667E+00	6.421E+00	6.183E+00
ZN 65	2.210E-05	2.775E-06	3.474E-07	4.363E-08	1.936E-09	1.078E-11	6.008E-14	3.338E-16	1.860E-18	1.036E-20
SE 79	3.638E-01	3.638E-01	3.637E-01	3.637E-01	3.637E-01	3.637E-01	3.637E-01	3.637E-01	3.636E-01	3.636E-01
KR 85	2.571E+03	2.260E+03	1.985E+03	1.745E+03	1.437E+03	1.040E+03	7.528E+02	5.448E+02	3.943E+02	2.854E+02
RB 87	1.429E-05	1.429E-05	1.429E-05	1.429E-05	1.429E-05	1.429E-05	1.429E-05	1.429E-05	1.429E-05	1.429E-05
SR 89	3.538E-25	1.574E-29	6.909E-34	3.073E-38	8.998E-45	1.172E-55	1.526E-66	1.960E-77	2.553E-88	3.325E-99
SR 90	2.553E+04	2.435E+04	2.321E+04	2.214E+04	2.061E+04	1.830E+04	1.624E+04	1.442E+04	1.280E+04	1.137E+04
Y 90	2.554E+04	2.435E+04	2.322E+04	2.214E+04	2.061E+04	1.830E+04	1.625E+04	1.442E+04	1.281E+04	1.137E+04
Y 91	4.610E-21	8.085E-25	1.401E-28	2.458E-32	5.642E-38	2.271E-47	9.145E-57	3.639E-66	1.464E-75	5.897E-85
ZR 93	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.496E-01	8.495E-01
ZR 95	7.539E-19	2.771E-22	1.008E-25	3.704E-29	2.583E-34	6.620E-43	1.697E-51	4.302E-60	1.103E-68	2.826E-77
NB 93M	4.569E-01	4.908E-01	5.215E-01	5.491E-01	5.857E-01	6.355E-01	6.741E-01	7.040E-01	7.272E-01	7.452E-01
NB 94	2.305E-02	2.304E-02	2.304E-02	2.304E-02	2.304E-02	2.303E-02	2.303E-02	2.303E-02	2.302E-02	2.302E-02
NB 95	1.674E-18	6.153E-22	2.238E-25	8.225E-29	5.734E-34	1.470E-42	3.767E-51	9.551E-60	2.448E-68	6.274E-77
NB 95M	5.593E-21	2.056E-24	7.477E-28	2.748E-31	1.916E-36	4.911E-45	1.259E-53	3.191E-62	8.179E-71	2.097E-79
MO 93	4.197E-03	4.195E-03	4.194E-03	4.192E-03	4.190E-03	4.186E-03	4.181E-03	4.177E-03	4.173E-03	4.169E-03
TC 99	3.341E+00	3.341E+00	3.341E+00	3.341E+00	3.341E+00	3.341E+00	3.341E+00	3.340E+00	3.340E+00	3.340E+00
RU103	2.868E-34	7.303E-40	1.827E-45	4.651E-51	1.856E-59	1.886E-73	1.916E-87	1.913-101	1.944-115	1.976-129
RU106	1.040E+00	2.630E-01	6.643E-02	1.681E-02	2.135E-03	6.860E-05	2.205E-06	7.072E-08	2.273E-09	7.303E-11
RH103M	2.586E-34	6.583E-40	1.647E-45	4.192E-51	1.673E-59	1.700E-73	1.728E-87	1.725-101	1.753-115	1.781-129
RH106	1.040E+00	2.630E-01	6.643E-02	1.681E-02	2.135E-03	6.860E-05	2.205E-06	7.072E-08	2.273E-09	7.303E-11
PD107	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03	3.543E-03
AG110	1.330E-06	1.755E-07	2.311E-08	3.050E-09	1.459E-10	9.210E-13	5.814E-15	3.660E-17	2.311E-19	1.459E-21
AG110M	9.998E-05	1.320E-05	1.737E-06	2.293E-07	1.097E-08	6.924E-11	4.371E-13	2.752E-15	1.738E-17	1.097E-19
AG111	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD113M	2.379E+00	2.163E+00	1.967E+00	1.789E+00	1.551E+00	1.223E+00	9.646E-01	7.606E-01	5.998E-01	4.730E-01
CD113	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD115M	1.230E-32	1.452E-37	1.688E-42	1.994E-47	7.968E-55	3.760E-67	1.775E-79	8.248E-92	3.892-104	1.837-116
IN114	5.523E-30	2.014E-34	7.240E-39	2.640E-43	5.730E-50	4.536E-61	3.589E-72	2.802E-83	2.218E-94	1.756-105
IN114M	5.771E-30	2.104E-34	7.565E-39	2.758E-43	5.987E-50	4.739E-61	3.751E-72	2.928E-83	2.318E-94	1.834-105
IN115M	8.635E-37	1.020E-41	1.186E-46	1.401E-51	5.597E-59	2.641E-71	1.247E-83	5.793E-96	2.734-108	1.290-120
SN119M	1.831E-03	2.322E-04	2.936E-05	3.723E-06	1.676E-07	9.572E-10	5.465E-12	3.111E-14	1.777E-16	1.014E-18
SN121M	4.988E-01	4.852E-01	4.719E-01	4.590E-01	4.403E-01	4.109E-01	3.833E-01	3.576E-01	3.336E-01	3.113E-01

SN123	1.178E-09	2.344E-11	4.639E-13	9.226E-15	2.575E-17	1.429E-21	7.936E-26	4.381E-30	2.433E-34	1.351E-38
SN125	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SN126	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.091E-01
SB124	1.678E-23	3.751E-27	8.290E-31	1.854E-34	6.126E-40	4.527E-49	3.344E-58	2.443E-67	1.805E-76	1.334E-85
SB125	1.713E+02	1.039E+02	6.293E+01	3.816E+01	1.801E+01	5.155E+00	1.475E+00	4.220E-01	1.208E-01	3.457E-02
SB126	5.729E-02	5.729E-02	5.729E-02	5.729E-02	5.729E-02	5.729E-02	5.729E-02	5.728E-02	5.728E-02	5.728E-02
SB126M	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.092E-01	4.091E-01
TE123M	8.484E-13	1.237E-14	1.793E-16	2.615E-18	4.577E-21	1.168E-25	2.982E-30	7.565E-35	1.931E-39	4.928E-44
TE125M	4.179E+01	2.535E+01	1.536E+01	9.315E+00	4.395E+00	1.258E+00	3.600E-01	1.030E-01	2.947E-02	8.434E-03
TE127	6.358E-11	6.128E-13	5.869E-15	5.657E-17	5.319E-20	4.821E-25	4.369E-30	3.935E-35	3.566E-40	3.232E-45
TE127M	6.491E-11	6.256E-13	5.992E-15	5.776E-17	5.431E-20	4.922E-25	4.461E-30	4.017E-35	3.641E-40	3.299E-45
TE129	1.012E-41	2.916E-48	8.233E-55	2.373E-61	3.596E-71	1.570E-87	6.858E-104	2.934E-120	1.282E-136	5.597E-153
TE129M	1.555E-41	4.480E-48	1.265E-54	3.645E-61	5.524E-71	2.412E-87	1.054E-103	4.508E-120	1.969E-136	8.598E-153
I129	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02	1.628E-02
I131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE131M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE133	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS134	3.540E+02	1.808E+02	9.226E+01	4.712E+01	1.719E+01	3.201E+00	5.962E-01	1.110E-01	2.067E-02	3.850E-03
CS135	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01	2.941E-01
CS136	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS137	2.489E+04	2.377E+04	2.270E+04	2.167E+04	2.022E+04	1.802E+04	1.605E+04	1.430E+04	1.274E+04	1.135E+04
BA136M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA137M	2.355E+04	2.249E+04	2.147E+04	2.050E+04	1.913E+04	1.704E+04	1.518E+04	1.353E+04	1.205E+04	1.074E+04
BA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE141	1.078E-41	1.877E-48	3.199E-55	5.570E-62	3.961E-72	4.904E-89	6.072E-106	7.360E-123	9.112E-140	1.128E-156
CE142	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05	1.019E-05
CE144	1.024E+00	1.727E-01	2.905E-02	4.898E-03	3.384E-04	3.941E-06	4.591E-08	5.335E-10	6.214E-12	7.239E-14
PR143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR144	1.024E+00	1.727E-01	2.905E-02	4.899E-03	3.384E-04	3.942E-06	4.591E-08	5.335E-10	6.215E-12	7.239E-14
PR144M	1.229E-02	2.072E-03	3.486E-04	5.878E-05	4.060E-06	4.730E-08	5.510E-10	6.402E-12	7.458E-14	8.687E-16
ND144	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10	4.220E-10
ND147	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

PM145	6.376E-03	5.896E-03	5.451E-03	5.041E-03	4.482E-03	3.685E-03	3.030E-03	2.491E-03	2.048E-03	1.684E-03
PM147	7.756E+02	4.574E+02	2.696E+02	1.590E+02	7.195E+01	1.920E+01	5.125E+00	1.367E+00	3.648E-01	9.738E-02
PM148M	3.430E-33	1.637E-38	7.680E-44	3.664E-49	3.756E-57	1.837E-70	8.982E-84	4.319E-97	2.112E-110	1.033E-123
PM148	1.932E-34	9.219E-40	4.326E-45	2.064E-50	2.115E-58	1.035E-71	5.059E-85	2.433E-98	1.190E-111	5.819E-125
SM145	2.050E-06	4.630E-07	1.043E-07	2.356E-08	2.523E-09	6.102E-11	1.476E-12	3.561E-14	8.613E-16	2.083E-17
SM147	1.284E-06	1.292E-06	1.297E-06	1.299E-06	1.301E-06	1.303E-06	1.303E-06	1.303E-06	1.303E-06	1.303E-06
SM151	1.313E+02	1.293E+02	1.273E+02	1.253E+02	1.225E+02	1.179E+02	1.134E+02	1.091E+02	1.050E+02	1.011E+02
EU152	1.334E+00	1.205E+00	1.088E+00	9.824E-01	8.431E-01	6.535E-01	5.065E-01	3.925E-01	3.043E-01	2.358E-01
EU154	4.955E+02	4.219E+02	3.590E+02	3.056E+02	2.399E+02	1.604E+02	1.072E+02	7.162E+01	4.787E+01	3.199E+01
EU155	1.353E+02	1.023E+02	7.735E+01	5.850E+01	3.846E+01	1.912E+01	9.507E+00	4.725E+00	2.349E+00	1.168E+00
EU156	1.880E-96	6.350E-111	2.049E-125	6.919E-140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	2.632E-05	3.254E-06	4.010E-07	4.956E-08	2.147E-09	1.150E-11	6.156E-14	3.286E-16	1.760E-18	9.422E-21
TB160	3.184E-20	2.909E-23	2.632E-26	2.404E-29	6.574E-34	1.642E-41	4.102E-49	1.015E-56	2.534E-64	6.331E-72
TL206	1.459E-12	1.459E-12	1.459E-12	1.459E-12	1.459E-12	1.459E-12	1.459E-12	1.459E-12	1.459E-12	1.459E-12
TL207	4.868E-01	5.329E-01	5.762E-01	6.167E-01	6.728E-01	7.551E-01	8.254E-01	8.854E-01	9.365E-01	9.801E-01
TL208	1.757E+02	1.729E+02	1.698E+02	1.667E+02	1.619E+02	1.541E+02	1.469E+02	1.400E+02	1.334E+02	1.271E+02
PB210	1.371E-04	1.326E-04	1.288E-04	1.258E-04	1.224E-04	1.200E-04	1.210E-04	1.250E-04	1.318E-04	1.410E-04
PB211	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01
PB212	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02
BI211	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01
BI212	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02
PO212	3.134E+02	3.083E+02	3.028E+02	2.972E+02	2.886E+02	2.749E+02	2.620E+02	2.496E+02	2.379E+02	2.267E+02
PO215	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01
PO216	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02
RN219	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01
RN220	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02
FR223	6.725E-03	7.360E-03	7.957E-03	8.517E-03	9.293E-03	1.043E-02	1.140E-02	1.223E-02	1.294E-02	1.354E-02
RA223	4.882E-01	5.344E-01	5.778E-01	6.184E-01	6.747E-01	7.572E-01	8.277E-01	8.879E-01	9.391E-01	9.828E-01
RA224	4.891E+02	4.812E+02	4.726E+02	4.639E+02	4.505E+02	4.290E+02	4.089E+02	3.896E+02	3.713E+02	3.539E+02
RA226	5.858E-05	6.637E-05	7.430E-05	8.234E-05	9.464E-05	1.158E-04	1.376E-04	1.603E-04	1.837E-04	2.079E-04
RA228	4.067E-02	4.198E-02	4.303E-02	4.389E-02	4.489E-02	4.600E-02	4.666E-02	4.706E-02	4.729E-02	4.743E-02
AC227	4.873E-01	5.334E-01	5.766E-01	6.172E-01	6.734E-01	7.559E-01	8.262E-01	8.862E-01	9.374E-01	9.810E-01
TH227	4.815E-01	5.271E-01	5.698E-01	6.099E-01	6.654E-01	7.468E-01	8.163E-01	8.757E-01	9.262E-01	9.693E-01

TH228	4.881E+02	4.799E+02	4.714E+02	4.627E+02	4.497E+02	4.286E+02	4.085E+02	3.893E+02	3.710E+02	3.536E+02
TH229	2.202E-01	2.445E-01	2.689E-01	2.933E-01	3.298E-01	3.906E-01	4.514E-01	5.122E-01	5.730E-01	6.337E-01
TH230	8.986E-03	9.137E-03	9.288E-03	9.439E-03	9.665E-03	1.004E-02	1.042E-02	1.080E-02	1.118E-02	1.155E-02
TH231	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04
TH232	4.764E-02	4.764E-02	4.764E-02	4.764E-02	4.764E-02	4.764E-02	4.764E-02	4.764E-02	4.764E-02	4.764E-02
TH234	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05
PA231	1.234E+00	1.234E+00	1.234E+00	1.234E+00	1.234E+00	1.234E+00	1.234E+00	1.234E+00	1.234E+00	1.234E+00
PA233	1.271E-03	1.272E-03	1.273E-03	1.274E-03	1.276E-03	1.279E-03	1.283E-03	1.286E-03	1.290E-03	1.294E-03
PA234M	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05
PA234	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08
U232	4.774E+02	4.683E+02	4.593E+02	4.506E+02	4.378E+02	4.172E+02	3.976E+02	3.789E+02	3.611E+02	3.441E+02
U233	1.292E+02	1.292E+02	1.292E+02	1.292E+02	1.292E+02	1.292E+02	1.292E+02	1.292E+02	1.292E+02	1.292E+02
U234	8.397E+00	8.397E+00	8.397E+00	8.397E+00	8.397E+00	8.397E+00	8.397E+00	8.397E+00	8.397E+00	8.397E+00
U235	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04	6.271E-04
U236	1.363E-03	1.363E-03	1.363E-03	1.363E-03	1.363E-03	1.363E-03	1.363E-03	1.363E-03	1.363E-03	1.363E-03
U237	1.037E-05	9.418E-06	8.553E-06	7.768E-06	6.723E-06	5.285E-06	4.155E-06	3.266E-06	2.567E-06	2.018E-06
U238	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05
NP237	1.271E-03	1.272E-03	1.273E-03	1.274E-03	1.276E-03	1.279E-03	1.283E-03	1.286E-03	1.290E-03	1.294E-03
PU236	2.084E-05	1.282E-05	7.883E-06	4.850E-06	2.340E-06	6.959E-07	2.083E-07	6.364E-08	2.078E-08	8.072E-09
PU237	3.810E-36	5.779E-41	8.632E-46	1.309E-50	7.615E-58	6.719E-70	5.928E-82	5.151E-94	4.544-106	4.009-118
PU238	5.164E+00	5.083E+00	5.004E+00	4.925E+00	4.810E+00	4.625E+00	4.446E+00	4.274E+00	4.109E+00	3.951E+00
PU239	2.823E-01	2.823E-01	2.823E-01	2.823E-01	2.822E-01	2.822E-01	2.822E-01	2.821E-01	2.821E-01	2.820E-01
PU240	1.658E-01	1.658E-01	1.658E-01	1.658E-01	1.659E-01	1.659E-01	1.659E-01	1.659E-01	1.659E-01	1.658E-01
PU241	4.227E+01	3.839E+01	3.486E+01	3.167E+01	2.741E+01	2.154E+01	1.694E+01	1.331E+01	1.046E+01	8.227E+00
PU242	4.184E-04	4.184E-04	4.184E-04	4.184E-04	4.184E-04	4.184E-04	4.185E-04	4.185E-04	4.185E-04	4.185E-04
PU244	5.389E-11	5.389E-11	5.389E-11	5.389E-11	5.389E-11	5.389E-11	5.389E-11	5.389E-11	5.389E-11	5.389E-11
AM241	1.456E+00	1.580E+00	1.692E+00	1.793E+00	1.926E+00	2.105E+00	2.241E+00	2.344E+00	2.420E+00	2.474E+00
AM242M	1.676E-02	1.660E-02	1.645E-02	1.630E-02	1.608E-02	1.572E-02	1.537E-02	1.502E-02	1.468E-02	1.435E-02
AM242	1.667E-02	1.652E-02	1.637E-02	1.622E-02	1.600E-02	1.564E-02	1.529E-02	1.494E-02	1.461E-02	1.428E-02
AM243	3.199E-03	3.199E-03	3.198E-03	3.198E-03	3.197E-03	3.195E-03	3.194E-03	3.192E-03	3.191E-03	3.189E-03
CM242	1.382E-02	1.369E-02	1.356E-02	1.344E-02	1.326E-02	1.294E-02	1.265E-02	1.236E-02	1.209E-02	1.181E-02
CM243	5.283E-03	5.032E-03	4.793E-03	4.565E-03	4.244E-03	3.758E-03	3.328E-03	2.947E-03	2.609E-03	2.311E-03
CM244	3.293E-01	3.051E-01	2.826E-01	2.618E-01	2.334E-01	1.927E-01	1.592E-01	1.314E-01	1.085E-01	8.964E-02

CM245	7.145E-05	7.143E-05	7.142E-05	7.141E-05	7.139E-05	7.136E-05	7.134E-05	7.131E-05	7.128E-05	7.125E-05
CM246	4.737E-06	4.735E-06	4.734E-06	4.732E-06	4.730E-06	4.727E-06	4.723E-06	4.720E-06	4.716E-06	4.713E-06
CM247	1.674E-11	1.674E-11	1.674E-11	1.674E-11	1.674E-11	1.674E-11	1.674E-11	1.674E-11	1.674E-11	1.674E-11
AP+ACT+FP	1.085E+05	1.029E+05	9.771E+04	9.295E+04	8.640E+04	7.669E+04	6.820E+04	6.072E+04	5.411E+04	4.826E+04

**Table 2-5B. Isotopic Activity Concentrations in Curies for a single LWBR
Standard Blanket Module (TYPE I).**

Information:

Units: CURIES
Burnup: 13,555.10 MWd (max)
Burnup: 12551.74 MWd/MTHM
BOL U-233: 16,471.46 grams U-233 per module
BOL U-234: 216.31 grams U-234 per module
BOL U-235: 15.09 grams U-235 per module
BOL U-236: 3.35 grams U-236 per module
BOL U-238: 62.04 grams U-238 per module
BOL Th-232: 1319931.77 grams Th-232 per module
Fuel Meat: UO₂-ThO₂ (Urania-Thoria)
Fuel Enrichment: 98.23 wt% U-233
Clad: Zircaloy-4

DECAY DATES										
ISOTOPE	01-Jul-96	01-Jul-98	01-Jul-00	01-Jul-02	01-Jul-05	01-Jul-10	01-Jul-15	01-Jul-20	01-Jul-25	01-Jul-30
H 3	9.651E+01	8.627E+01	7.711E+01	6.892E+01	5.824E+01	4.399E+01	3.323E+01	2.509E+01	1.895E+01	1.432E+01
BE 10	3.869E-06	3.869E-06	3.869E-06	3.869E-06	3.869E-06	3.869E-06	3.869E-06	3.869E-06	3.869E-06	3.869E-06
C 14	1.712E+00	1.711E+00	1.711E+00	1.711E+00	1.710E+00	1.709E+00	1.708E+00	1.707E+00	1.706E+00	1.705E+00
CL 36	4.182E-02	4.182E-02	4.182E-02	4.182E-02	4.182E-02	4.182E-02	4.182E-02	4.181E-02	4.181E-02	4.181E-02
CR 51	3.524E-52	4.132E-60	4.725E-68	5.539E-76	6.859E-88	9.958E-108	1.446E-127	2.047E-147	2.972E-167	4.314E-187
MN 54	6.309E-04	1.249E-04	2.469E-05	4.890E-06	4.301E-07	7.492E-09	1.305E-10	2.268E-12	3.951E-14	6.882E-16
FE 55	9.369E+00	5.499E+00	3.225E+00	1.893E+00	8.506E-01	2.243E-01	5.917E-02	1.559E-02	4.113E-03	1.085E-03
FE 59	3.634E-33	4.753E-38	6.122E-43	8.008E-48	3.731E-55	2.273E-67	1.385E-79	8.312E-92	5.065E-104	3.086E-116
CO 60	2.552E+02	1.962E+02	1.508E+02	1.159E+02	7.812E+01	4.047E+01	2.097E+01	1.086E+01	5.627E+00	2.915E+00
NI 59	1.405E-01	1.404E-01	1.404E-01	1.404E-01	1.404E-01	1.404E-01	1.404E-01	1.404E-01	1.404E-01	1.404E-01
NI 63	1.700E+01	1.675E+01	1.650E+01	1.625E+01	1.589E+01	1.530E+01	1.474E+01	1.419E+01	1.367E+01	1.316E+01

ZN 65	2.528E-05	3.175E-06	3.975E-07	4.991E-08	2.215E-09	1.234E-11	6.874E-14	3.819E-16	2.128E-18	1.185E-20
SE 79	4.782E-01	4.782E-01	4.782E-01	4.782E-01	4.782E-01	4.781E-01	4.781E-01	4.781E-01	4.781E-01	4.780E-01
KR 85	3.415E+03	3.001E+03	2.636E+03	2.317E+03	1.908E+03	1.381E+03	9.997E+02	7.234E+02	5.236E+02	3.790E+02
RB 87	1.902E-05	1.902E-05	1.902E-05	1.902E-05	1.902E-05	1.902E-05	1.902E-05	1.902E-05	1.902E-05	1.902E-05
SR 89	4.691E-25	2.087E-29	9.161E-34	4.075E-38	1.193E-44	1.554E-55	2.023E-66	2.599E-77	3.385E-88	4.409E-99
SR 90	3.379E+04	3.222E+04	3.072E+04	2.929E+04	2.727E+04	2.421E+04	2.150E+04	1.908E+04	1.694E+04	1.504E+04
Y 90	3.380E+04	3.223E+04	3.073E+04	2.930E+04	2.728E+04	2.422E+04	2.150E+04	1.909E+04	1.695E+04	1.505E+04
Y 91	6.098E-21	1.069E-24	1.854E-28	3.251E-32	7.463E-38	3.004E-47	1.209E-56	4.813E-66	1.937E-75	7.800E-85
ZR 93	1.126E+00	1.126E+00	1.126E+00	1.126E+00	1.126E+00	1.126E+00	1.126E+00	1.126E+00	1.126E+00	1.126E+00
ZR 95	9.859E-19	3.624E-22	1.318E-25	4.845E-29	3.378E-34	8.658E-43	2.219E-51	5.627E-60	1.442E-68	3.696E-77
NB 93M	6.061E-01	6.511E-01	6.917E-01	7.284E-01	7.768E-01	8.428E-01	8.939E-01	9.335E-01	9.642E-01	9.880E-01
NB 94	3.098E-02	3.097E-02	3.097E-02	3.097E-02	3.097E-02	3.096E-02	3.096E-02	3.095E-02	3.095E-02	3.094E-02
NB 95	2.189E-18	8.046E-22	2.926E-25	1.075E-28	7.499E-34	1.922E-42	4.927E-51	1.249E-59	3.202E-68	8.205E-77
NB 95M	7.314E-21	2.689E-24	9.777E-28	3.594E-31	2.506E-36	6.423E-45	1.646E-53	4.174E-62	1.070E-70	2.742E-79
MO 93	8.749E-03	8.745E-03	8.742E-03	8.738E-03	8.733E-03	8.725E-03	8.716E-03	8.707E-03	8.699E-03	8.690E-03
TC 99	4.471E+00	4.471E+00	4.471E+00	4.471E+00	4.471E+00	4.471E+00	4.471E+00	4.471E+00	4.471E+00	4.471E+00
RU103	3.759E-34	9.569E-40	2.394E-45	6.094E-51	2.432E-59	2.471E-73	2.511E-87	2.507-101	2.548-115	2.589-129
RU106	1.360E+00	3.440E-01	8.686E-02	2.198E-02	2.792E-03	8.971E-05	2.883E-06	9.247E-08	2.972E-09	9.550E-11
RH103M	3.388E-34	8.627E-40	2.158E-45	5.494E-51	2.193E-59	2.228E-73	2.264E-87	2.260-101	2.297-115	2.334-129
RH106	1.360E+00	3.440E-01	8.686E-02	2.198E-02	2.792E-03	8.971E-05	2.883E-06	9.247E-08	2.972E-09	9.550E-11
PD107	4.673E-03	4.673E-03	4.673E-03	4.673E-03	4.673E-03	4.673E-03	4.673E-03	4.673E-03	4.673E-03	4.673E-03
AG110	1.189E-06	1.570E-07	2.067E-08	2.728E-09	1.305E-10	8.238E-13	5.201E-15	3.274E-17	2.067E-19	1.305E-21
AG110M	8.943E-05	1.181E-05	1.554E-06	2.051E-07	9.811E-09	6.194E-11	3.910E-13	2.462E-15	1.554E-17	9.812E-20
AG111	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD113M	2.942E+00	2.675E+00	2.432E+00	2.212E+00	1.918E+00	1.513E+00	1.193E+00	9.405E-01	7.417E-01	5.849E-01
CD113	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD115M	1.639E-32	1.935E-37	2.250E-42	2.657E-47	1.062E-54	5.012E-67	2.366E-79	1.100E-91	5.188-104	2.449-116
IN114	4.824E-30	1.759E-34	6.323E-39	2.305E-43	5.004E-50	3.961E-61	3.135E-72	2.447E-83	1.937E-94	1.533-105
IN114M	5.041E-30	1.838E-34	6.607E-39	2.409E-43	5.230E-50	4.139E-61	3.276E-72	2.557E-83	2.024E-94	1.602-105
IN115M	1.151E-36	1.359E-41	1.581E-46	1.867E-51	7.461E-59	3.521E-71	1.662E-83	7.723E-96	3.645-108	1.720-120
SN119M	2.108E-03	2.673E-04	3.379E-05	4.285E-06	1.930E-07	1.102E-09	6.290E-12	3.582E-14	2.044E-16	1.168E-18
SN121M	6.561E-01	6.381E-01	6.206E-01	6.037E-01	5.790E-01	5.403E-01	5.040E-01	4.703E-01	4.388E-01	4.093E-01
SN123	1.501E-09	2.986E-11	5.908E-13	1.175E-14	3.279E-17	1.821E-21	1.011E-25	5.581E-30	3.098E-34	1.720E-38

SN125	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SN126	5.351E-01	5.351E-01	5.351E-01	5.351E-01	5.351E-01	5.351E-01	5.351E-01	5.350E-01	5.350E-01	5.350E-01
SB124	1.440E-23	3.219E-27	7.114E-31	1.590E-34	5.257E-40	3.885E-49	2.870E-58	2.096E-67	1.549E-76	1.145E-85
SB125	2.233E+02	1.354E+02	8.207E+01	4.977E+01	2.348E+01	6.722E+00	1.924E+00	5.502E-01	1.575E-01	4.507E-02
SB126	7.492E-02	7.492E-02	7.492E-02	7.492E-02	7.491E-02	7.491E-02	7.491E-02	7.491E-02	7.490E-02	7.490E-02
SB126M	5.351E-01	5.351E-01	5.351E-01	5.351E-01	5.351E-01	5.351E-01	5.351E-01	5.350E-01	5.350E-01	5.350E-01
TE123M	5.542E-13	8.081E-15	1.171E-16	1.708E-18	2.990E-21	7.631E-26	1.947E-30	4.942E-35	1.261E-39	3.219E-44
TE125M	5.448E+01	3.305E+01	2.003E+01	1.215E+01	5.731E+00	1.640E+00	4.694E-01	1.342E-01	3.842E-02	1.100E-02
TE127	8.394E-11	8.091E-13	7.749E-15	7.469E-17	7.023E-20	6.365E-25	5.768E-30	5.195E-35	4.708E-40	4.267E-45
TE127M	8.570E-11	8.260E-13	7.911E-15	7.625E-17	7.170E-20	6.498E-25	5.889E-30	5.303E-35	4.806E-40	4.356E-45
TE129	1.336E-41	3.851E-48	1.087E-54	3.133E-61	4.748E-71	2.074E-87	9.057-104	3.875-120	1.692-136	7.391-153
TE129M	2.053E-41	5.916E-48	1.670E-54	4.813E-61	7.294E-71	3.186E-87	1.391-103	5.953-120	2.600-136	1.135-152
I129	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02	2.155E-02
I131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE131M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE133	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS134	3.812E+02	1.947E+02	9.936E+01	5.075E+01	1.851E+01	3.447E+00	6.421E-01	1.195E-01	2.226E-02	4.146E-03
CS135	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01	3.653E-01
CS136	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS137	3.286E+04	3.138E+04	2.996E+04	2.861E+04	2.669E+04	2.378E+04	2.119E+04	1.887E+04	1.682E+04	1.498E+04
BA136M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA137M	3.109E+04	2.969E+04	2.834E+04	2.706E+04	2.525E+04	2.250E+04	2.004E+04	1.786E+04	1.591E+04	1.417E+04
BA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE141	1.427E-41	2.485E-48	4.236E-55	7.374E-62	5.244E-72	6.493E-89	8.039-106	9.744-123	1.206-139	1.494-156
CE142	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05	1.344E-05
CE144	1.359E+00	2.292E-01	3.856E-02	6.502E-03	4.491E-04	5.232E-06	6.094E-08	7.081E-10	8.249E-12	9.609E-14
PR143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR144	1.359E+00	2.292E-01	3.856E-02	6.502E-03	4.491E-04	5.232E-06	6.094E-08	7.082E-10	8.249E-12	9.609E-14
PR144M	1.631E-02	2.751E-03	4.627E-04	7.802E-05	5.390E-06	6.278E-08	7.313E-10	8.498E-12	9.899E-14	1.153E-15
ND144	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10	5.608E-10
ND147	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM145	8.478E-03	7.840E-03	7.249E-03	6.704E-03	5.960E-03	4.901E-03	4.029E-03	3.313E-03	2.724E-03	2.239E-03

PM147	1.191E+03	7.022E+02	4.138E+02	2.441E+02	1.105E+02	2.948E+01	7.868E+00	2.099E+00	5.601E-01	1.495E-01
PM148M	3.409E-33	1.627E-38	7.632E-44	3.642E-49	3.732E-57	1.825E-70	8.926E-84	4.293E-97	2.099E-110	1.027E-123
PM148	1.920E-34	9.162E-40	4.299E-45	2.051E-50	2.102E-58	1.028E-71	5.028E-85	2.418E-98	1.182E-111	5.782E-125
SM145	2.457E-06	5.548E-07	1.250E-07	2.823E-08	3.024E-09	7.312E-11	1.768E-12	4.267E-14	1.032E-15	2.496E-17
SM147	1.954E-06	1.966E-06	1.973E-06	1.977E-06	1.980E-06	1.982E-06	1.983E-06	1.983E-06	1.983E-06	1.983E-06
SM151	1.589E+02	1.564E+02	1.540E+02	1.517E+02	1.482E+02	1.426E+02	1.373E+02	1.321E+02	1.271E+02	1.223E+02
EU152	2.550E+00	2.302E+00	2.080E+00	1.878E+00	1.611E+00	1.249E+00	9.681E-01	7.502E-01	5.815E-01	4.507E-01
EU154	5.409E+02	4.604E+02	3.918E+02	3.335E+02	2.619E+02	1.750E+02	1.170E+02	7.817E+01	5.225E+01	3.492E+01
EU155	1.475E+02	1.115E+02	8.430E+01	6.374E+01	4.191E+01	2.084E+01	1.036E+01	5.150E+00	2.561E+00	1.273E+00
EU156	1.921E-96	6.489E-111	2.094E-125	7.071E-140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	2.130E-05	2.632E-06	3.243E-07	4.009E-08	1.736E-09	9.299E-12	4.979E-14	2.659E-16	1.423E-18	7.621E-21
TB160	2.784E-20	2.543E-23	2.301E-26	2.102E-29	5.747E-34	1.435E-41	3.585E-49	8.871E-57	2.216E-64	5.535E-72
TL206	1.261E-12	1.261E-12	1.261E-12	1.261E-12	1.261E-12	1.261E-12	1.261E-12	1.261E-12	1.261E-12	1.261E-12
TL207	1.058E+00	1.156E+00	1.247E+00	1.333E+00	1.452E+00	1.626E+00	1.775E+00	1.902E+00	2.010E+00	2.103E+00
TL208	2.884E+02	2.837E+02	2.786E+02	2.734E+02	2.656E+02	2.529E+02	2.410E+02	2.297E+02	2.189E+02	2.086E+02
PB210	1.697E-04	1.662E-04	1.639E-04	1.625E-04	1.621E-04	1.658E-04	1.742E-04	1.869E-04	2.034E-04	2.233E-04
PB211	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00
PB212	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02
BI211	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00
BI212	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02
PO212	5.143E+02	5.059E+02	4.968E+02	4.876E+02	4.735E+02	4.509E+02	4.298E+02	4.096E+02	3.903E+02	3.720E+02
PO215	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00
PO216	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02
RN219	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00
RN220	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02
FR223	1.461E-02	1.596E-02	1.723E-02	1.841E-02	2.005E-02	2.246E-02	2.452E-02	2.627E-02	2.777E-02	2.904E-02
RA223	1.061E+00	1.159E+00	1.251E+00	1.337E+00	1.456E+00	1.631E+00	1.780E+00	1.907E+00	2.016E+00	2.109E+00
RA224	8.027E+02	7.896E+02	7.754E+02	7.611E+02	7.391E+02	7.038E+02	6.708E+02	6.393E+02	6.092E+02	5.806E+02
RA226	1.062E-04	1.199E-04	1.337E-04	1.478E-04	1.691E-04	2.055E-04	2.430E-04	2.815E-04	3.211E-04	3.616E-04
RA228	1.219E-01	1.257E-01	1.289E-01	1.314E-01	1.344E-01	1.377E-01	1.397E-01	1.408E-01	1.415E-01	1.419E-01
AC227	1.059E+00	1.157E+00	1.248E+00	1.334E+00	1.453E+00	1.628E+00	1.777E+00	1.904E+00	2.012E+00	2.105E+00
TH227	1.046E+00	1.143E+00	1.234E+00	1.318E+00	1.436E+00	1.608E+00	1.756E+00	1.881E+00	1.988E+00	2.080E+00
TH228	8.010E+02	7.875E+02	7.734E+02	7.591E+02	7.377E+02	7.032E+02	6.702E+02	6.387E+02	6.087E+02	5.801E+02

TH229	3.428E-01	3.811E-01	4.195E-01	4.578E-01	5.153E-01	6.111E-01	7.068E-01	8.025E-01	8.981E-01	9.937E-01
TH230	1.581E-02	1.602E-02	1.623E-02	1.643E-02	1.674E-02	1.726E-02	1.778E-02	1.830E-02	1.882E-02	1.933E-02
TH231	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04
TH232	1.426E-01	1.426E-01	1.426E-01	1.426E-01	1.426E-01	1.426E-01	1.426E-01	1.426E-01	1.426E-01	1.426E-01
TH234	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05
PA231	2.641E+00	2.641E+00	2.641E+00	2.641E+00	2.641E+00	2.641E+00	2.640E+00	2.640E+00	2.640E+00	2.640E+00
PA233	1.182E-03	1.183E-03	1.184E-03	1.185E-03	1.186E-03	1.189E-03	1.193E-03	1.196E-03	1.199E-03	1.203E-03
PA234M	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05
PA234	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08	2.358E-08
U232	7.831E+02	7.682E+02	7.536E+02	7.392E+02	7.181E+02	6.844E+02	6.522E+02	6.216E+02	5.924E+02	5.645E+02
U233	2.034E+02	2.034E+02	2.034E+02	2.034E+02	2.034E+02	2.034E+02	2.034E+02	2.034E+02	2.034E+02	2.034E+02
U234	1.153E+01	1.153E+01	1.153E+01	1.153E+01	1.153E+01	1.152E+01	1.152E+01	1.152E+01	1.152E+01	1.152E+01
U235	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04	7.749E-04
U236	1.523E-03	1.523E-03	1.523E-03	1.523E-03	1.523E-03	1.523E-03	1.523E-03	1.523E-03	1.523E-03	1.523E-03
U237	9.216E-06	8.371E-06	7.602E-06	6.904E-06	5.976E-06	4.698E-06	3.693E-06	2.903E-06	2.282E-06	1.794E-06
U238	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05	1.814E-05
NP237	1.182E-03	1.183E-03	1.184E-03	1.185E-03	1.186E-03	1.189E-03	1.193E-03	1.196E-03	1.199E-03	1.203E-03
PU236	1.155E-05	7.106E-06	4.369E-06	2.688E-06	1.297E-06	3.855E-07	1.154E-07	3.520E-08	1.145E-08	4.405E-09
PU237	1.680E-36	2.547E-41	3.805E-46	5.771E-51	3.357E-58	2.962E-70	2.613E-82	2.271E-94	2.003-106	1.767-118
PU238	4.516E+00	4.446E+00	4.376E+00	4.308E+00	4.207E+00	4.045E+00	3.888E+00	3.738E+00	3.594E+00	3.455E+00
PU239	2.430E-01	2.430E-01	2.430E-01	2.429E-01	2.429E-01	2.429E-01	2.429E-01	2.428E-01	2.428E-01	2.428E-01
PU240	1.481E-01	1.481E-01	1.481E-01	1.481E-01	1.482E-01	1.482E-01	1.482E-01	1.482E-01	1.481E-01	1.481E-01
PU241	3.757E+01	3.412E+01	3.099E+01	2.815E+01	2.436E+01	1.915E+01	1.505E+01	1.183E+01	9.301E+00	7.312E+00
PU242	4.069E-04	4.070E-04	4.070E-04	4.070E-04	4.070E-04	4.070E-04	4.070E-04	4.070E-04	4.070E-04	4.070E-04
PU244	4.173E-11	4.173E-11	4.173E-11	4.173E-11	4.173E-11	4.173E-11	4.173E-11	4.173E-11	4.173E-11	4.173E-11
AM241	1.317E+00	1.427E+00	1.527E+00	1.617E+00	1.735E+00	1.894E+00	2.014E+00	2.105E+00	2.172E+00	2.221E+00
AM242M	1.194E-02	1.183E-02	1.172E-02	1.162E-02	1.146E-02	1.120E-02	1.095E-02	1.070E-02	1.046E-02	1.022E-02
AM242	1.188E-02	1.177E-02	1.167E-02	1.156E-02	1.140E-02	1.115E-02	1.089E-02	1.065E-02	1.041E-02	1.017E-02
AM243	3.053E-03	3.052E-03	3.051E-03	3.051E-03	3.050E-03	3.049E-03	3.047E-03	3.046E-03	3.044E-03	3.043E-03
CM242	9.844E-03	9.753E-03	9.665E-03	9.577E-03	9.450E-03	9.221E-03	9.013E-03	8.810E-03	8.612E-03	8.418E-03
CM243	4.174E-03	3.976E-03	3.787E-03	3.607E-03	3.354E-03	2.970E-03	2.630E-03	2.328E-03	2.062E-03	1.826E-03
CM244	2.685E-01	2.487E-01	2.304E-01	2.134E-01	1.903E-01	1.571E-01	1.298E-01	1.072E-01	8.849E-02	7.308E-02
CM245	4.965E-05	4.964E-05	4.963E-05	4.962E-05	4.961E-05	4.959E-05	4.957E-05	4.955E-05	4.953E-05	4.951E-05

CM246	3.660E-06	3.659E-06	3.658E-06	3.657E-06	3.655E-06	3.653E-06	3.650E-06	3.647E-06	3.645E-06	3.642E-06
CM247	1.150E-11	1.150E-11	1.150E-11	1.150E-11	1.150E-11	1.150E-11	1.150E-11	1.150E-11	1.150E-11	1.150E-11
SUBTOTAL	1.447E+05	1.372E+05	1.303E+05	1.240E+05	1.153E+05	1.025E+05	9.119E+04	8.125E+04	7.248E+04	6.470E+04
AP+ACT+FP	1.447E+05	1.372E+05	1.303E+05	1.240E+05	1.153E+05	1.025E+05	9.119E+04	8.126E+04	7.248E+04	6.471E+04

**Table 2-5C. Isotopic Activity Concentrations in Curies for a single LWBR
Standard/Power Flattening (PF) Blanket Module (TYPE II).**

Information:

Units: CURIES
Burnup: 15098.75 MWd (max)
Burnup: 9682.70 MWd/MTHM
BOL U-233: 25020.61 grams U-233 per module
BOL U-234: 328.58 grams U-234 per module
BOL U-235: 22.92 grams U-235 per module
BOL U-236: 5.10 grams U-236 per module
BOL U-238: 94.24 grams U-238 per module
BOL Th-232: 1533876.10 grams Th-232 per module
Fuel Meat: UO₂-ThO₂ (Urania-Thoria)
Fuel Enrichment: 98.23 wt% U-233
Clad: Zircaloy-4

DECAY DATES										
ISOTOPE	01-Jul-96	01-Jul-98	01-Jul-00	01-Jul-02	01-Jul-05	01-Jul-10	01-Jul-15	01-Jul-20	01-Jul-25	01-Jul-30
H 3	1.073E+02	9.588E+01	8.569E+01	7.660E+01	6.472E+01	4.889E+01	3.693E+01	2.789E+01	2.106E+01	1.591E+01
BE 10	3.663E-06	3.663E-06	3.663E-06	3.663E-06	3.663E-06	3.663E-06	3.663E-06	3.663E-06	3.663E-06	3.663E-06
C 14	1.650E+00	1.649E+00	1.649E+00	1.648E+00	1.648E+00	1.647E+00	1.646E+00	1.645E+00	1.644E+00	1.643E+00
CL 36	4.026E-02	4.026E-02	4.026E-02	4.026E-02	4.026E-02	4.026E-02	4.026E-02	4.025E-02	4.025E-02	4.025E-02
CR 51	3.732E-52	4.376E-60	5.004E-68	5.867E-76	7.264E-88	1.055-107	1.531-127	2.168-147	3.147-167	4.569-187
MN 54	6.473E-04	1.282E-04	2.534E-05	5.018E-06	4.413E-07	7.688E-09	1.339E-10	2.327E-12	4.054E-14	7.062E-16
FE 55	9.354E+00	5.491E+00	3.220E+00	1.890E+00	8.493E-01	2.240E-01	5.908E-02	1.557E-02	4.106E-03	1.083E-03
FE 59	3.763E-33	4.922E-38	6.339E-43	8.292E-48	3.863E-55	2.354E-67	1.434E-79	8.607E-92	5.245-104	3.196-116
CO 60	2.516E+02	1.935E+02	1.487E+02	1.143E+02	7.704E+01	3.991E+01	2.068E+01	1.071E+01	5.549E+00	2.875E+00
NI 59	1.376E-01	1.376E-01	1.376E-01	1.376E-01	1.376E-01	1.376E-01	1.376E-01	1.376E-01	1.376E-01	1.376E-01
NI 63	1.638E+01	1.614E+01	1.589E+01	1.566E+01	1.531E+01	1.474E+01	1.420E+01	1.367E+01	1.317E+01	1.268E+01

ZN 65	2.650E-05	3.328E-06	4.167E-07	5.232E-08	2.322E-09	1.293E-11	7.206E-14	4.003E-16	2.230E-18	1.243E-20
SE 79	5.349E-01	5.349E-01	5.349E-01	5.349E-01	5.349E-01	5.349E-01	5.348E-01	5.348E-01	5.348E-01	5.347E-01
KR 85	3.789E+03	3.329E+03	2.925E+03	2.571E+03	2.117E+03	1.532E+03	1.109E+03	8.027E+02	5.810E+02	4.205E+02
RB 87	2.112E-05	2.112E-05	2.112E-05	2.112E-05	2.112E-05	2.112E-05	2.112E-05	2.112E-05	2.112E-05	2.112E-05
SR 89	5.220E-25	2.322E-29	1.019E-33	4.534E-38	1.327E-44	1.729E-55	2.251E-66	2.892E-77	3.766E-88	4.905E-99
SR 90	3.762E+04	3.587E+04	3.420E+04	3.261E+04	3.037E+04	2.696E+04	2.394E+04	2.125E+04	1.886E+04	1.675E+04
Y 90	3.763E+04	3.588E+04	3.421E+04	3.262E+04	3.037E+04	2.697E+04	2.394E+04	2.125E+04	1.887E+04	1.675E+04
Y 91	6.786E-21	1.190E-24	2.063E-28	3.618E-32	8.305E-38	3.343E-47	1.346E-56	5.355E-66	2.156E-75	8.679E-85
ZR 93	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00	1.241E+00
ZR 95	1.096E-18	4.028E-22	1.464E-25	5.384E-29	3.754E-34	9.622E-43	2.466E-51	6.252E-60	1.603E-68	4.108E-77
NB 93M	6.675E-01	7.170E-01	7.618E-01	8.022E-01	8.556E-01	9.283E-01	9.846E-01	1.028E+00	1.062E+00	1.088E+00
NB 94	3.123E-02	3.123E-02	3.122E-02	3.122E-02	3.122E-02	3.121E-02	3.121E-02	3.120E-02	3.120E-02	3.119E-02
NB 95	2.432E-18	8.943E-22	3.252E-25	1.196E-28	8.335E-34	2.136E-42	5.476E-51	1.388E-59	3.558E-68	9.119E-77
NB 95M	8.128E-21	2.988E-24	1.087E-27	3.994E-31	2.785E-36	7.138E-45	1.830E-53	4.639E-62	1.189E-70	3.047E-79
MO 93	8.376E-03	8.373E-03	8.370E-03	8.367E-03	8.362E-03	8.353E-03	8.345E-03	8.337E-03	8.328E-03	8.320E-03
TC 99	5.066E+00	5.065E+00	5.065E+00	5.065E+00	5.065E+00	5.065E+00	5.065E+00	5.065E+00	5.065E+00	5.065E+00
RU103	4.186E-34	1.066E-39	2.666E-45	6.788E-51	2.709E-59	2.753E-73	2.797E-87	2.793-101	2.838-115	2.883-129
RU106	1.519E+00	3.844E-01	9.707E-02	2.456E-02	3.119E-03	1.002E-04	3.222E-06	1.033E-07	3.321E-09	1.067E-10
RH103M	3.774E-34	9.608E-40	2.403E-45	6.119E-51	2.442E-59	2.482E-73	2.522E-87	2.517-101	2.558-115	2.599-129
RH106	1.519E+00	3.844E-01	9.707E-02	2.456E-02	3.119E-03	1.002E-04	3.222E-06	1.033E-07	3.321E-09	1.067E-10
PD107	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03	5.246E-03
AG110	1.197E-06	1.580E-07	2.080E-08	2.746E-09	1.313E-10	8.291E-13	5.234E-15	3.295E-17	2.080E-19	1.313E-21
AG110M	9.000E-05	1.188E-05	1.564E-06	2.064E-07	9.874E-09	6.233E-11	3.935E-13	2.478E-15	1.564E-17	9.875E-20
AG111	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD113M	3.133E+00	2.849E+00	2.591E+00	2.356E+00	2.043E+00	1.611E+00	1.271E+00	1.002E+00	7.900E-01	6.230E-01
CD113	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD115M	1.802E-32	2.128E-37	2.474E-42	2.922E-47	1.168E-54	5.511E-67	2.601E-79	1.209E-91	5.705-104	2.692-116
IN114	4.298E-30	1.567E-34	5.635E-39	2.054E-43	4.460E-50	3.530E-61	2.794E-72	2.181E-83	1.726E-94	1.366-105
IN114M	4.492E-30	1.637E-34	5.888E-39	2.147E-43	4.660E-50	3.688E-61	2.919E-72	2.279E-83	1.804E-94	1.428-105
IN115M	1.266E-36	1.495E-41	1.738E-46	2.053E-51	8.203E-59	3.872E-71	1.827E-83	8.491E-96	4.007-108	1.891-120
SN119M	2.213E-03	2.806E-04	3.548E-05	4.498E-06	2.026E-07	1.157E-09	6.603E-12	3.759E-14	2.146E-16	1.225E-18
SN121M	6.731E-01	6.547E-01	6.368E-01	6.194E-01	5.941E-01	5.543E-01	5.172E-01	4.825E-01	4.502E-01	4.201E-01
SN123	1.658E-09	3.299E-11	6.527E-13	1.299E-14	3.623E-17	2.011E-21	1.117E-25	6.166E-30	3.423E-34	1.900E-38

SN125	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SN126	5.999E-01	5.999E-01	5.998E-01	5.998E-01	5.998E-01	5.998E-01	5.998E-01	5.998E-01	5.997E-01	5.997E-01
SB124	1.410E-23	3.153E-27	6.970E-31	1.559E-34	5.151E-40	3.805E-49	2.812E-58	2.054E-67	1.518E-76	1.121E-85
SB125	2.459E+02	1.492E+02	9.039E+01	5.481E+01	2.587E+01	7.404E+00	2.119E+00	6.061E-01	1.735E-01	4.964E-02
SB126	8.398E-02	8.398E-02	8.398E-02	8.398E-02	8.398E-02	8.397E-02	8.397E-02	8.397E-02	8.396E-02	8.396E-02
SB126M	5.999E-01	5.999E-01	5.998E-01	5.998E-01	5.998E-01	5.998E-01	5.998E-01	5.998E-01	5.997E-01	5.997E-01
TE123M	4.183E-13	6.099E-15	8.841E-17	1.289E-18	2.257E-21	5.759E-26	1.470E-30	3.730E-35	9.520E-40	2.429E-44
TE125M	6.001E+01	3.640E+01	2.206E+01	1.338E+01	6.311E+00	1.806E+00	5.170E-01	1.479E-01	4.232E-02	1.211E-02
TE127	9.393E-11	9.053E-13	8.671E-15	8.357E-17	7.858E-20	7.122E-25	6.455E-30	5.813E-35	5.268E-40	4.774E-45
TE127M	9.589E-11	9.243E-13	8.852E-15	8.532E-17	8.023E-20	7.271E-25	6.590E-30	5.934E-35	5.378E-40	4.874E-45
TE129	1.494E-41	4.304E-48	1.215E-54	3.502E-61	5.307E-71	2.318E-87	1.012-103	4.331-120	1.892-136	8.261-153
TE129M	2.295E-41	6.613E-48	1.867E-54	5.380E-61	8.153E-71	3.561E-87	1.555-103	6.653-120	2.906-136	1.269-152
I129	2.430E-02	2.430E-02	2.430E-02	2.430E-02	2.430E-02	2.430E-02	2.430E-02	2.430E-02	2.430E-02	2.430E-02
I131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE131M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE133	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS134	3.722E+02	1.901E+02	9.700E+01	4.954E+01	1.807E+01	3.365E+00	6.269E-01	1.167E-01	2.173E-02	4.047E-03
CS135	4.358E-01	4.358E-01	4.358E-01	4.358E-01	4.358E-01	4.358E-01	4.358E-01	4.358E-01	4.358E-01	4.358E-01
CS136	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS137	3.662E+04	3.497E+04	3.339E+04	3.188E+04	2.974E+04	2.650E+04	2.361E+04	2.103E+04	1.874E+04	1.669E+04
BA136M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA137M	3.464E+04	3.308E+04	3.158E+04	3.016E+04	2.814E+04	2.507E+04	2.233E+04	1.990E+04	1.773E+04	1.579E+04
BA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE141	1.589E-41	2.766E-48	4.714E-55	8.207E-62	5.836E-72	7.226E-89	8.946-106	1.084-122	1.343-139	1.662-156
CE142	1.499E-05	1.499E-05	1.499E-05	1.499E-05	1.499E-05	1.499E-05	1.499E-05	1.499E-05	1.499E-05	1.499E-05
CE144	1.510E+00	2.545E-01	4.282E-02	7.221E-03	4.988E-04	5.810E-06	6.768E-08	7.864E-10	9.161E-12	1.067E-13
PR143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR144	1.510E+00	2.546E-01	4.282E-02	7.221E-03	4.988E-04	5.810E-06	6.768E-08	7.865E-10	9.161E-12	1.067E-13
PR144M	1.811E-02	3.055E-03	5.138E-04	8.665E-05	5.985E-06	6.972E-08	8.121E-10	9.437E-12	1.099E-13	1.281E-15
ND144	6.110E-10	6.110E-10	6.110E-10	6.110E-10	6.110E-10	6.110E-10	6.110E-10	6.110E-10	6.110E-10	6.110E-10
ND147	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM145	8.551E-03	7.907E-03	7.311E-03	6.761E-03	6.011E-03	4.943E-03	4.064E-03	3.341E-03	2.747E-03	2.259E-03

PM147	1.423E+03	8.393E+02	4.946E+02	2.917E+02	1.320E+02	3.524E+01	9.404E+00	2.508E+00	6.695E-01	1.787E-01
PM148M	3.749E-33	1.789E-38	8.394E-44	4.005E-49	4.105E-57	2.007E-70	9.817E-84	4.721E-97	2.309E-110	1.129E-123
PM148	2.112E-34	1.008E-39	4.728E-45	2.256E-50	2.312E-58	1.131E-71	5.529E-85	2.659E-98	1.300E-111	6.359E-125
SM145	2.579E-06	5.824E-07	1.313E-07	2.964E-08	3.174E-09	7.676E-11	1.856E-12	4.480E-14	1.083E-15	2.620E-17
SM147	2.363E-06	2.377E-06	2.386E-06	2.391E-06	2.394E-06	2.397E-06	2.397E-06	2.398E-06	2.398E-06	2.398E-06
SM151	1.919E+02	1.889E+02	1.860E+02	1.832E+02	1.790E+02	1.722E+02	1.657E+02	1.594E+02	1.534E+02	1.476E+02
EU152	3.499E+00	3.160E+00	2.854E+00	2.577E+00	2.212E+00	1.714E+00	1.329E+00	1.029E+00	7.981E-01	6.186E-01
EU154	5.113E+02	4.352E+02	3.704E+02	3.152E+02	2.475E+02	1.655E+02	1.106E+02	7.388E+01	4.938E+01	3.300E+01
EU155	1.400E+02	1.059E+02	8.004E+01	6.053E+01	3.980E+01	1.979E+01	9.839E+00	4.890E+00	2.431E+00	1.208E+00
EU156	1.684E-96	5.688E-111	1.835E-125	6.197E-140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	2.534E-05	3.132E-06	3.860E-07	4.771E-08	2.067E-09	1.107E-11	5.926E-14	3.164E-16	1.694E-18	9.071E-21
TB160	2.701E-20	2.467E-23	2.232E-26	2.039E-29	5.575E-34	1.393E-41	3.479E-49	8.606E-57	2.150E-64	5.370E-72
TL206	1.321E-12	1.321E-12	1.321E-12	1.321E-12	1.321E-12	1.321E-12	1.321E-12	1.321E-12	1.321E-12	1.321E-12
TL207	1.120E+00	1.224E+00	1.321E+00	1.412E+00	1.537E+00	1.722E+00	1.880E+00	2.014E+00	2.129E+00	2.227E+00
TL208	2.528E+02	2.487E+02	2.442E+02	2.397E+02	2.328E+02	2.217E+02	2.113E+02	2.014E+02	1.919E+02	1.829E+02
PB210	1.261E-04	1.255E-04	1.257E-04	1.268E-04	1.300E-04	1.390E-04	1.522E-04	1.693E-04	1.897E-04	2.133E-04
PB211	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00
PB212	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02
BI211	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00
BI212	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02
PO212	4.508E+02	4.435E+02	4.355E+02	4.275E+02	4.151E+02	3.953E+02	3.768E+02	3.591E+02	3.422E+02	3.261E+02
PO215	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00
PO216	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02
RN219	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00
RN220	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02
FR223	1.548E-02	1.690E-02	1.824E-02	1.949E-02	2.123E-02	2.379E-02	2.597E-02	2.782E-02	2.941E-02	3.075E-02
RA223	1.124E+00	1.227E+00	1.324E+00	1.416E+00	1.542E+00	1.727E+00	1.885E+00	2.020E+00	2.135E+00	2.233E+00
RA224	7.037E+02	6.922E+02	6.798E+02	6.672E+02	6.479E+02	6.170E+02	5.881E+02	5.604E+02	5.341E+02	5.090E+02
RA226	1.082E-04	1.224E-04	1.367E-04	1.512E-04	1.733E-04	2.112E-04	2.503E-04	2.906E-04	3.320E-04	3.747E-04
RA228	1.421E-01	1.466E-01	1.503E-01	1.532E-01	1.567E-01	1.605E-01	1.628E-01	1.641E-01	1.650E-01	1.654E-01
AC227	1.121E+00	1.225E+00	1.322E+00	1.413E+00	1.539E+00	1.724E+00	1.882E+00	2.016E+00	2.131E+00	2.229E+00
TH227	1.108E+00	1.210E+00	1.306E+00	1.396E+00	1.520E+00	1.703E+00	1.859E+00	1.992E+00	2.105E+00	2.202E+00
TH228	7.021E+02	6.904E+02	6.780E+02	6.655E+02	6.468E+02	6.165E+02	5.875E+02	5.599E+02	5.336E+02	5.086E+02

TH229	4.352E-01	4.841E-01	5.330E-01	5.818E-01	6.551E-01	7.772E-01	8.993E-01	1.021E+00	1.143E+00	1.265E+00
TH230	1.631E-02	1.654E-02	1.678E-02	1.702E-02	1.737E-02	1.797E-02	1.856E-02	1.916E-02	1.975E-02	2.035E-02
TH231	7.946E-04	7.946E-04	7.946E-04	7.947E-04	7.947E-04	7.947E-04	7.947E-04	7.947E-04	7.947E-04	7.947E-04
TH232	1.661E-01	1.661E-01	1.661E-01	1.661E-01	1.661E-01	1.661E-01	1.661E-01	1.661E-01	1.661E-01	1.661E-01
TH234	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05
PA231	2.797E+00	2.797E+00	2.797E+00	2.797E+00	2.797E+00	2.796E+00	2.796E+00	2.796E+00	2.795E+00	2.795E+00
PA233	1.101E-03	1.102E-03	1.103E-03	1.104E-03	1.106E-03	1.110E-03	1.113E-03	1.117E-03	1.121E-03	1.125E-03
PA234M	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05
PA234	3.674E-08	3.674E-08	3.674E-08	3.674E-08	3.674E-08	3.674E-08	3.674E-08	3.674E-08	3.674E-08	3.674E-08
U232	6.865E+02	6.734E+02	6.606E+02	6.480E+02	6.295E+02	6.000E+02	5.718E+02	5.449E+02	5.193E+02	4.949E+02
U233	2.593E+02	2.593E+02	2.593E+02	2.593E+02	2.593E+02	2.593E+02	2.593E+02	2.593E+02	2.593E+02	2.593E+02
U234	1.322E+01	1.322E+01	1.322E+01	1.322E+01	1.322E+01	1.322E+01	1.322E+01	1.322E+01	1.322E+01	1.322E+01
U235	7.946E-04	7.946E-04	7.946E-04	7.947E-04	7.947E-04	7.947E-04	7.947E-04	7.947E-04	7.947E-04	7.947E-04
U236	1.470E-03	1.470E-03	1.470E-03	1.470E-03	1.470E-03	1.470E-03	1.470E-03	1.470E-03	1.470E-03	1.470E-03
U237	1.024E-05	9.305E-06	8.450E-06	7.675E-06	6.643E-06	5.222E-06	4.105E-06	3.227E-06	2.537E-06	1.994E-06
U238	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05	2.826E-05
NP237	1.101E-03	1.102E-03	1.103E-03	1.104E-03	1.106E-03	1.110E-03	1.113E-03	1.117E-03	1.121E-03	1.125E-03
PU236	9.911E-06	6.097E-06	3.748E-06	2.306E-06	1.113E-06	3.309E-07	9.903E-08	3.026E-08	9.883E-09	3.839E-09
PU237	1.294E-36	1.962E-41	2.931E-46	4.446E-51	2.586E-58	2.282E-70	2.013E-82	1.749E-94	1.543E-106	1.362E-118
PU238	3.889E+00	3.828E+00	3.768E+00	3.709E+00	3.623E+00	3.483E+00	3.348E+00	3.219E+00	3.094E+00	2.975E+00
PU239	3.480E-01	3.480E-01	3.480E-01	3.480E-01	3.480E-01	3.479E-01	3.479E-01	3.478E-01	3.478E-01	3.477E-01
PU240	1.954E-01	1.954E-01	1.954E-01	1.953E-01	1.953E-01	1.953E-01	1.952E-01	1.951E-01	1.951E-01	1.950E-01
PU241	4.176E+01	3.793E+01	3.445E+01	3.129E+01	2.708E+01	2.129E+01	1.673E+01	1.315E+01	1.034E+01	8.128E+00
PU242	3.590E-04	3.590E-04	3.590E-04	3.590E-04	3.590E-04	3.590E-04	3.590E-04	3.591E-04	3.591E-04	3.591E-04
PU244	2.417E-11	2.417E-11	2.417E-11	2.417E-11	2.417E-11	2.417E-11	2.417E-11	2.417E-11	2.417E-11	2.417E-11
AM241	1.458E+00	1.581E+00	1.691E+00	1.791E+00	1.922E+00	2.099E+00	2.233E+00	2.334E+00	2.409E+00	2.463E+00
AM242M	1.178E-02	1.168E-02	1.157E-02	1.146E-02	1.131E-02	1.105E-02	1.081E-02	1.056E-02	1.032E-02	1.009E-02
AM242	1.172E-02	1.162E-02	1.151E-02	1.141E-02	1.125E-02	1.100E-02	1.075E-02	1.051E-02	1.027E-02	1.004E-02
AM243	2.243E-03	2.243E-03	2.242E-03	2.242E-03	2.241E-03	2.240E-03	2.239E-03	2.238E-03	2.237E-03	2.236E-03
CM242	9.715E-03	9.625E-03	9.538E-03	9.451E-03	9.325E-03	9.100E-03	8.895E-03	8.694E-03	8.499E-03	8.307E-03
CM243	3.072E-03	2.926E-03	2.787E-03	2.655E-03	2.468E-03	2.185E-03	1.935E-03	1.714E-03	1.517E-03	1.344E-03
CM244	1.567E-01	1.451E-01	1.344E-01	1.245E-01	1.110E-01	9.169E-02	7.572E-02	6.253E-02	5.164E-02	4.265E-02
CM245	2.390E-05	2.390E-05	2.389E-05	2.389E-05	2.388E-05	2.387E-05	2.386E-05	2.385E-05	2.384E-05	2.383E-05

CM246	1.398E-06	1.397E-06	1.397E-06	1.397E-06	1.396E-06	1.395E-06	1.394E-06	1.393E-06	1.392E-06	1.391E-06
CM247	3.556E-12	3.556E-12	3.556E-12	3.556E-12	3.556E-12	3.556E-12	3.556E-12	3.556E-12	3.556E-12	3.556E-12
AP+ACT+FP	1.596E+05	1.513E+05	1.437E+05	1.367E+05	1.271E+05	1.128E+05	1.003E+05	8.933E+04	7.961E+04	7.101E+04

**Table 2-5D. Isotopic Activity Concentrations in Curies for a single LWBR
Standard/Power Flattening (PF) Blanket Module (TYPE III).**

Information:

Units: CURIES
Burnup: 14558.84 MWd (max)
Burnup: 8555.73 MWd/MTHM
BOL U-233: 29415.81 grams U-233 per module
BOL U-234: 386.30 grams U-234 per module
BOL U-235: 26.95 grams U-235 per module
BOL U-236: 5.99 grams U-236 per module
BOL U-238: 110.80 grams U-238 per module
BOL Th-232: 1671701.60 grams Th-232 per module
Fuel Meat: UO₂-ThO₂ (Urania-Thoria)
Fuel Enrichment: 98.23 wt% U-233
Clad: Zircaloy-4

DECAY DATES										
ISOTOPE	01-Jul-96	01-Jul-98	01-Jul-00	01-Jul-02	01-Jul-05	01-Jul-10	01-Jul-15	01-Jul-20	01-Jul-25	01-Jul-30
H 3	1.034E+02	9.239E+01	8.257E+01	7.381E+01	6.237E+01	4.711E+01	3.558E+01	2.687E+01	2.030E+01	1.533E+01
BE 10	3.265E-06	3.265E-06	3.265E-06	3.265E-06	3.265E-06	3.265E-06	3.265E-06	3.265E-06	3.265E-06	3.265E-06
C 14	1.503E+00	1.502E+00	1.502E+00	1.502E+00	1.501E+00	1.500E+00	1.499E+00	1.498E+00	1.497E+00	1.496E+00
CL 36	3.716E-02	3.716E-02	3.716E-02	3.716E-02	3.716E-02	3.716E-02	3.716E-02	3.716E-02	3.716E-02	3.716E-02
CR 51	3.425E-52	4.016E-60	4.593E-68	5.385E-76	6.667E-88	9.679-108	1.405-127	1.990-147	2.889-167	4.193-187
MN 54	5.905E-04	1.169E-04	2.311E-05	4.577E-06	4.026E-07	7.012E-09	1.221E-10	2.123E-12	3.698E-14	6.442E-16
FE 55	8.472E+00	4.973E+00	2.916E+00	1.712E+00	7.692E-01	2.029E-01	5.350E-02	1.410E-02	3.719E-03	9.808E-04
FE 59	3.425E-33	4.480E-38	5.771E-43	7.549E-48	3.517E-55	2.143E-67	1.306E-79	7.835E-92	4.774-104	2.909-116
CO 60	2.311E+02	1.777E+02	1.366E+02	1.050E+02	7.076E+01	3.666E+01	1.899E+01	9.838E+00	5.097E+00	2.641E+00
NI 59	1.282E-01	1.281E-01	1.281E-01	1.281E-01	1.281E-01	1.281E-01	1.281E-01	1.281E-01	1.281E-01	1.281E-01
NI 63	1.506E+01	1.484E+01	1.461E+01	1.440E+01	1.407E+01	1.355E+01	1.305E+01	1.257E+01	1.211E+01	1.166E+01

ZN 65	2.390E-05	3.001E-06	3.758E-07	4.719E-08	2.094E-09	1.166E-11	6.499E-14	3.610E-16	2.011E-18	1.121E-20
SE 79	5.168E-01	5.168E-01	5.167E-01	5.167E-01	5.167E-01	5.167E-01	5.167E-01	5.166E-01	5.166E-01	5.166E-01
KR 85	3.648E+03	3.206E+03	2.817E+03	2.476E+03	2.039E+03	1.476E+03	1.068E+03	7.730E+02	5.595E+02	4.049E+02
RB 87	2.036E-05	2.036E-05	2.036E-05	2.036E-05	2.036E-05	2.036E-05	2.036E-05	2.036E-05	2.036E-05	2.036E-05
SR 89	5.032E-25	2.239E-29	9.827E-34	4.372E-38	1.280E-44	1.667E-55	2.171E-66	2.788E-77	3.631E-88	4.729E-99
SR 90	3.628E+04	3.459E+04	3.298E+04	3.145E+04	2.928E+04	2.600E+04	2.308E+04	2.049E+04	1.819E+04	1.615E+04
Y 90	3.629E+04	3.460E+04	3.299E+04	3.146E+04	2.929E+04	2.601E+04	2.309E+04	2.050E+04	1.820E+04	1.616E+04
Y 91	6.541E-21	1.147E-24	1.988E-28	3.487E-32	8.005E-38	3.222E-47	1.297E-56	5.162E-66	2.078E-75	8.366E-85
ZR 93	1.188E+00	1.188E+00	1.188E+00	1.188E+00	1.188E+00	1.188E+00	1.188E+00	1.188E+00	1.188E+00	1.188E+00
ZR 95	1.053E-18	3.873E-22	1.408E-25	5.177E-29	3.609E-34	9.251E-43	2.371E-51	6.012E-60	1.541E-68	3.949E-77
NB 93M	6.391E-01	6.865E-01	7.294E-01	7.680E-01	8.192E-01	8.887E-01	9.427E-01	9.845E-01	1.017E+00	1.042E+00
NB 94	2.802E-02	2.802E-02	2.802E-02	2.801E-02	2.801E-02	2.801E-02	2.800E-02	2.800E-02	2.799E-02	2.799E-02
NB 95	2.339E-18	8.598E-22	3.127E-25	1.149E-28	8.013E-34	2.054E-42	5.264E-51	1.335E-59	3.421E-68	8.768E-77
NB 95M	7.815E-21	2.873E-24	1.045E-27	3.840E-31	2.678E-36	6.863E-45	1.759E-53	4.459E-62	1.143E-70	2.930E-79
MO 93	7.658E-03	7.655E-03	7.652E-03	7.649E-03	7.645E-03	7.637E-03	7.629E-03	7.622E-03	7.614E-03	7.607E-03
TC 99	4.947E+00	4.947E+00	4.947E+00	4.947E+00	4.947E+00	4.947E+00	4.947E+00	4.946E+00	4.946E+00	4.946E+00
RU103	4.031E-34	1.026E-39	2.567E-45	6.536E-51	2.609E-59	2.651E-73	2.693E-87	2.689-101	2.732-115	2.776-129
RU106	1.466E+00	3.708E-01	9.363E-02	2.369E-02	3.009E-03	9.670E-05	3.108E-06	9.968E-08	3.203E-09	1.029E-10
RH103M	3.634E-34	9.252E-40	2.314E-45	5.892E-51	2.352E-59	2.390E-73	2.428E-87	2.424-101	2.463-115	2.503-129
RH106	1.466E+00	3.708E-01	9.363E-02	2.369E-02	3.009E-03	9.670E-05	3.108E-06	9.968E-08	3.203E-09	1.029E-10
PD107	5.077E-03	5.077E-03	5.077E-03	5.077E-03	5.077E-03	5.077E-03	5.077E-03	5.077E-03	5.077E-03	5.077E-03
AG110	1.021E-06	1.347E-07	1.773E-08	2.341E-09	1.120E-10	7.068E-13	4.462E-15	2.809E-17	1.774E-19	1.120E-21
AG110M	7.673E-05	1.013E-05	1.333E-06	1.760E-07	8.418E-09	5.314E-11	3.355E-13	2.112E-15	1.334E-17	8.419E-20
AG111	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD113M	2.927E+00	2.662E+00	2.421E+00	2.201E+00	1.909E+00	1.505E+00	1.187E+00	9.360E-01	7.381E-01	5.821E-01
CD113	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD115M	1.728E-32	2.040E-37	2.372E-42	2.801E-47	1.119E-54	5.284E-67	2.494E-79	1.158E-91	5.469-104	2.581-116
IN114	3.332E-30	1.215E-34	4.367E-39	1.592E-43	3.456E-50	2.736E-61	2.166E-72	1.690E-83	1.337E-94	1.058-105
IN114M	3.482E-30	1.269E-34	4.564E-39	1.664E-43	3.612E-50	2.859E-61	2.262E-72	1.766E-83	1.397E-94	1.106-105
IN115M	1.213E-36	1.433E-41	1.667E-46	1.968E-51	7.865E-59	3.712E-71	1.752E-83	8.141E-96	3.842-108	1.814-120
SN119M	1.997E-03	2.533E-04	3.202E-05	4.062E-06	1.829E-07	1.044E-09	5.962E-12	3.394E-14	1.938E-16	1.107E-18
SN121M	6.120E-01	5.953E-01	5.789E-01	5.631E-01	5.401E-01	5.039E-01	4.702E-01	4.386E-01	4.093E-01	3.818E-01
SN123	1.582E-09	3.147E-11	6.227E-13	1.239E-14	3.456E-17	1.919E-21	1.065E-25	5.882E-30	3.265E-34	1.813E-38

SN125	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SN126	5.798E-01	5.798E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.796E-01	5.796E-01
SB124	1.175E-23	2.627E-27	5.806E-31	1.298E-34	4.291E-40	3.170E-49	2.343E-58	1.711E-67	1.265E-76	9.343E-86
SB125	2.348E+02	1.424E+02	8.629E+01	5.233E+01	2.470E+01	7.068E+00	2.023E+00	5.785E-01	1.656E-01	4.739E-02
SB126	8.117E-02	8.117E-02	8.116E-02	8.116E-02	8.116E-02	8.116E-02	8.116E-02	8.115E-02	8.115E-02	8.115E-02
SB126M	5.798E-01	5.798E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.797E-01	5.796E-01	5.796E-01
TE123M	2.801E-13	4.084E-15	5.920E-17	8.632E-19	1.511E-21	3.856E-26	9.843E-31	2.497E-35	6.375E-40	1.627E-44
TE125M	5.729E+01	3.476E+01	2.106E+01	1.277E+01	6.026E+00	1.724E+00	4.936E-01	1.411E-01	4.040E-02	1.156E-02
TE127	9.080E-11	8.752E-13	8.382E-15	8.079E-17	7.597E-20	6.885E-25	6.240E-30	5.619E-35	5.093E-40	4.616E-45
TE127M	9.270E-11	8.935E-13	8.558E-15	8.248E-17	7.756E-20	7.029E-25	6.370E-30	5.737E-35	5.199E-40	4.712E-45
TE129	1.443E-41	4.159E-48	1.174E-54	3.383E-61	5.127E-71	2.239E-87	9.780-104	4.184-120	1.827-136	7.981-153
TE129M	2.217E-41	6.389E-48	1.804E-54	5.198E-61	7.877E-71	3.440E-87	1.503-103	6.428-120	2.807-136	1.226-152
I129	2.360E-02	2.360E-02	2.360E-02	2.360E-02	2.360E-02	2.360E-02	2.360E-02	2.360E-02	2.360E-02	2.360E-02
I131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE131M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE133	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS134	3.112E+02	1.590E+02	8.112E+01	4.143E+01	1.511E+01	2.814E+00	5.242E-01	9.756E-02	1.817E-02	3.385E-03
CS135	4.430E-01	4.430E-01	4.430E-01	4.430E-01	4.430E-01	4.430E-01	4.430E-01	4.430E-01	4.430E-01	4.430E-01
CS136	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS137	3.532E+04	3.372E+04	3.220E+04	3.075E+04	2.869E+04	2.556E+04	2.277E+04	2.028E+04	1.807E+04	1.610E+04
BA136M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA137M	3.341E+04	3.190E+04	3.046E+04	2.909E+04	2.714E+04	2.418E+04	2.154E+04	1.919E+04	1.710E+04	1.523E+04
BA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE141	1.531E-41	2.666E-48	4.544E-55	7.911E-62	5.626E-72	6.966E-89	8.624-106	1.045-122	1.294-139	1.602-156
CE142	1.446E-05	1.446E-05	1.446E-05	1.446E-05	1.446E-05	1.446E-05	1.446E-05	1.446E-05	1.446E-05	1.446E-05
CE144	1.454E+00	2.452E-01	4.125E-02	6.955E-03	4.805E-04	5.597E-06	6.519E-08	7.575E-10	8.824E-12	1.028E-13
PR143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR144	1.454E+00	2.452E-01	4.125E-02	6.956E-03	4.805E-04	5.597E-06	6.519E-08	7.576E-10	8.825E-12	1.028E-13
PR144M	1.745E-02	2.942E-03	4.950E-04	8.347E-05	5.766E-06	6.716E-08	7.823E-10	9.091E-12	1.059E-13	1.233E-15
ND144	5.792E-10	5.792E-10	5.792E-10	5.792E-10	5.792E-10	5.792E-10	5.792E-10	5.792E-10	5.792E-10	5.792E-10
ND147	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM145	7.664E-03	7.087E-03	6.553E-03	6.060E-03	5.388E-03	4.430E-03	3.642E-03	2.994E-03	2.462E-03	2.024E-03

PM147	1.469E+03	8.663E+02	5.106E+02	3.011E+02	1.363E+02	3.637E+01	9.707E+00	2.589E+00	6.910E-01	1.844E-01
PM148M	3.492E-33	1.666E-38	7.817E-44	3.730E-49	3.823E-57	1.869E-70	9.142E-84	4.397E-97	2.150-110	1.051-123
PM148	1.967E-34	9.383E-40	4.403E-45	2.101E-50	2.153E-58	1.053E-71	5.149E-85	2.476E-98	1.211-111	5.922-125
SM145	2.337E-06	5.278E-07	1.190E-07	2.686E-08	2.877E-09	6.957E-11	1.682E-12	4.060E-14	9.818E-16	2.374E-17
SM147	2.452E-06	2.467E-06	2.475E-06	2.480E-06	2.484E-06	2.487E-06	2.488E-06	2.488E-06	2.488E-06	2.488E-06
SM151	2.036E+02	2.005E+02	1.975E+02	1.944E+02	1.900E+02	1.828E+02	1.760E+02	1.692E+02	1.628E+02	1.567E+02
EU152	4.119E+00	3.720E+00	3.359E+00	3.034E+00	2.603E+00	2.018E+00	1.564E+00	1.212E+00	9.396E-01	7.283E-01
EU154	4.131E+02	3.516E+02	2.992E+02	2.547E+02	2.000E+02	1.336E+02	8.933E+01	5.969E+01	3.989E+01	2.666E+01
EU155	1.176E+02	8.899E+01	6.727E+01	5.088E+01	3.345E+01	1.663E+01	8.269E+00	4.110E+00	2.043E+00	1.016E+00
EU156	1.295E-96	4.374-111	1.411-125	4.765-140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	2.496E-05	3.085E-06	3.801E-07	4.698E-08	2.036E-09	1.090E-11	5.835E-14	3.115E-16	1.668E-18	8.932E-21
TB160	2.229E-20	2.036E-23	1.843E-26	1.683E-29	4.602E-34	1.150E-41	2.871E-49	7.103E-57	1.774E-64	4.432E-72
TL206	1.228E-12	1.228E-12	1.228E-12	1.228E-12	1.228E-12	1.228E-12	1.228E-12	1.228E-12	1.228E-12	1.228E-12
TL207	1.114E+00	1.217E+00	1.313E+00	1.403E+00	1.528E+00	1.711E+00	1.868E+00	2.001E+00	2.115E+00	2.212E+00
TL208	2.127E+02	2.092E+02	2.054E+02	2.016E+02	1.958E+02	1.865E+02	1.777E+02	1.694E+02	1.614E+02	1.538E+02
PB210	9.378E-05	9.478E-05	9.654E-05	9.903E-05	1.041E-04	1.157E-04	1.309E-04	1.495E-04	1.711E-04	1.955E-04
PB211	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00
PB212	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02
BI211	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00
BI212	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02
PO212	3.792E+02	3.730E+02	3.663E+02	3.596E+02	3.492E+02	3.325E+02	3.169E+02	3.020E+02	2.878E+02	2.743E+02
PO215	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00
PO216	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02
RN219	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00
RN220	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02
FR223	1.539E-02	1.680E-02	1.813E-02	1.938E-02	2.110E-02	2.364E-02	2.580E-02	2.764E-02	2.921E-02	3.055E-02
RA223	1.117E+00	1.220E+00	1.317E+00	1.407E+00	1.532E+00	1.716E+00	1.873E+00	2.007E+00	2.121E+00	2.218E+00
RA224	5.919E+02	5.822E+02	5.718E+02	5.612E+02	5.450E+02	5.190E+02	4.946E+02	4.714E+02	4.493E+02	4.282E+02
RA226	1.036E-04	1.171E-04	1.309E-04	1.449E-04	1.662E-04	2.027E-04	2.404E-04	2.794E-04	3.195E-04	3.608E-04
RA228	1.553E-01	1.602E-01	1.641E-01	1.674E-01	1.711E-01	1.753E-01	1.778E-01	1.793E-01	1.801E-01	1.807E-01
AC227	1.115E+00	1.218E+00	1.314E+00	1.404E+00	1.529E+00	1.713E+00	1.869E+00	2.003E+00	2.117E+00	2.214E+00
TH227	1.102E+00	1.203E+00	1.299E+00	1.388E+00	1.511E+00	1.692E+00	1.847E+00	1.979E+00	2.091E+00	2.187E+00
TH228	5.906E+02	5.807E+02	5.703E+02	5.597E+02	5.440E+02	5.185E+02	4.942E+02	4.710E+02	4.489E+02	4.278E+02

TH229	4.915E-01	5.466E-01	6.018E-01	6.569E-01	7.395E-01	8.772E-01	1.015E+00	1.152E+00	1.290E+00	1.427E+00
TH230	1.567E-02	1.591E-02	1.615E-02	1.638E-02	1.674E-02	1.734E-02	1.793E-02	1.853E-02	1.912E-02	1.971E-02
TH231	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04
TH232	1.814E-01	1.814E-01	1.814E-01	1.814E-01	1.814E-01	1.814E-01	1.814E-01	1.814E-01	1.814E-01	1.814E-01
TH234	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05
PA231	2.778E+00	2.778E+00	2.777E+00	2.777E+00	2.777E+00	2.777E+00	2.777E+00	2.776E+00	2.776E+00	2.776E+00
PA233	9.167E-04	9.176E-04	9.185E-04	9.195E-04	9.210E-04	9.239E-04	9.269E-04	9.301E-04	9.334E-04	9.368E-04
PA234M	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05
PA234	4.403E-08	4.403E-08	4.403E-08	4.403E-08	4.403E-08	4.403E-08	4.403E-08	4.403E-08	4.403E-08	4.403E-08
U232	5.774E+02	5.664E+02	5.556E+02	5.450E+02	5.295E+02	5.046E+02	4.809E+02	4.583E+02	4.368E+02	4.162E+02
U233	2.924E+02	2.924E+02	2.924E+02	2.924E+02	2.924E+02	2.924E+02	2.924E+02	2.924E+02	2.924E+02	2.924E+02
U234	1.323E+01	1.323E+01	1.323E+01	1.323E+01	1.323E+01	1.323E+01	1.323E+01	1.323E+01	1.323E+01	1.323E+01
U235	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04	7.118E-04
U236	1.269E-03	1.269E-03	1.269E-03	1.269E-03	1.269E-03	1.269E-03	1.269E-03	1.269E-03	1.269E-03	1.269E-03
U237	8.861E-06	8.048E-06	7.309E-06	6.638E-06	5.745E-06	4.517E-06	3.551E-06	2.791E-06	2.194E-06	1.725E-06
U238	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05	3.387E-05
NP237	9.167E-04	9.176E-04	9.185E-04	9.195E-04	9.210E-04	9.239E-04	9.269E-04	9.301E-04	9.334E-04	9.368E-04
PU236	7.504E-06	4.616E-06	2.838E-06	1.746E-06	8.425E-07	2.506E-07	7.504E-08	2.296E-08	7.532E-09	2.956E-09
PU237	8.631E-37	1.309E-41	1.955E-46	2.965E-51	1.725E-58	1.522E-70	1.343E-82	1.167E-94	1.029-106	9.082-119
PU238	2.949E+00	2.903E+00	2.858E+00	2.813E+00	2.747E+00	2.641E+00	2.539E+00	2.441E+00	2.347E+00	2.256E+00
PU239	3.832E-01	3.832E-01	3.832E-01	3.831E-01	3.831E-01	3.831E-01	3.830E-01	3.830E-01	3.829E-01	3.828E-01
PU240	1.979E-01	1.979E-01	1.978E-01	1.978E-01	1.978E-01	1.977E-01	1.976E-01	1.975E-01	1.974E-01	1.973E-01
PU241	3.612E+01	3.281E+01	2.979E+01	2.706E+01	2.342E+01	1.841E+01	1.447E+01	1.138E+01	8.943E+00	7.030E+00
PU242	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04	2.552E-04
PU244	1.188E-11	1.188E-11	1.188E-11	1.188E-11	1.188E-11	1.188E-11	1.188E-11	1.188E-11	1.188E-11	1.188E-11
AM241	1.260E+00	1.366E+00	1.462E+00	1.548E+00	1.662E+00	1.815E+00	1.931E+00	2.018E+00	2.083E+00	2.130E+00
AM242M	9.293E-03	9.208E-03	9.125E-03	9.042E-03	8.919E-03	8.718E-03	8.522E-03	8.329E-03	8.142E-03	7.958E-03
AM242	9.246E-03	9.163E-03	9.079E-03	8.997E-03	8.875E-03	8.675E-03	8.479E-03	8.288E-03	8.101E-03	7.918E-03
AM243	1.357E-03	1.357E-03	1.357E-03	1.356E-03	1.356E-03	1.355E-03	1.355E-03	1.354E-03	1.353E-03	1.353E-03
CM242	7.662E-03	7.591E-03	7.522E-03	7.454E-03	7.355E-03	7.177E-03	7.015E-03	6.857E-03	6.703E-03	6.551E-03
CM243	1.849E-03	1.761E-03	1.678E-03	1.598E-03	1.485E-03	1.315E-03	1.165E-03	1.031E-03	9.133E-04	8.087E-04
CM244	7.792E-02	7.218E-02	6.686E-02	6.193E-02	5.521E-02	4.560E-02	3.766E-02	3.109E-02	2.568E-02	2.121E-02
CM245	1.005E-05	1.005E-05	1.004E-05	1.004E-05	1.004E-05	1.004E-05	1.003E-05	1.003E-05	1.002E-05	1.002E-05

CM246	4.834E-07	4.832E-07	4.831E-07	4.830E-07	4.827E-07	4.824E-07	4.820E-07	4.817E-07	4.813E-07	4.810E-07
CM247	1.026E-12	1.026E-12	1.026E-12	1.026E-12	1.026E-12	1.026E-12	1.026E-12	1.026E-12	1.026E-12	1.026E-12
AP+ACT+FP	1.532E+05	1.452E+05	1.379E+05	1.312E+05	1.219E+05	1.082E+05	9.621E+04	8.564E+04	7.630E+04	6.803E+04

**Table 2-5E. Isotopic Activity Concentrations in Curies for a single LWBR
Reflector Module (TYPE IV).**

Information: Units: CURIES
Burnup: MWd (max)
Burnup: MWd/MTHM
BOL U-233: 0 grams U-233 per module
BOL U-234: 0 grams U-234 per module
BOL U-235: 0 grams U-235 per module
BOL U-236: 0 grams U-236 per module
BOL U-238: 0 grams U-238 per module
BOL Th-232: 1438800.00 grams Th-232 per module
Fuel Meat: ThO₂ (Thoria)
Fuel Enrichment: 0.00 wt% U-233 at BOL
Clad: Zircaloy-4

REFLECTOR IV (or REFLECTOR 4)

DECAY DATES										
ISOTOPE	01-Jul-96	01-Jul-98	01-Jul-00	01-Jul-02	01-Jul-05	01-Jul-10	01-Jul-15	01-Jul-20	01-Jul-25	01-Jul-30
H 3	2.207E+00	1.973E+00	1.763E+00	1.576E+00	1.332E+00	1.006E+00	7.598E-01	5.738E-01	4.334E-01	3.273E-01
BE 10	5.229E-08	5.229E-08	5.229E-08	5.229E-08	5.229E-08	5.229E-08	5.229E-08	5.229E-08	5.229E-08	5.229E-08
C 14	3.603E-02	3.603E-02	3.602E-02	3.601E-02	3.599E-02	3.597E-02	3.595E-02	3.593E-02	3.591E-02	3.589E-02
CL 36	5.438E-07	5.438E-07	5.438E-07	5.438E-07	5.438E-07	5.437E-07	5.437E-07	5.437E-07	5.437E-07	5.437E-07
CR 51	1.240E-52	1.454E-60	1.663E-68	1.950E-76	2.414E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
MN 54	4.389E-05	8.692E-06	1.718E-06	3.402E-07	2.992E-08	5.212E-10	9.078E-12	1.578E-13	2.748E-15	4.788E-17
FE 55	5.602E-01	3.288E-01	1.929E-01	1.132E-01	5.086E-02	1.342E-02	3.538E-03	9.325E-04	2.459E-04	6.486E-05
FE 59	5.428E-34	7.099E-39	9.145E-44	1.196E-48	5.572E-56	3.395E-68	2.069E-80	1.242E-92	0.000E+00	0.000E+00
CO 60	7.530E+00	5.789E+00	4.449E+00	3.421E+00	2.305E+00	1.194E+00	6.188E-01	3.205E-01	1.660E-01	8.603E-02
NI 59	9.806E-04	9.805E-04	9.805E-04	9.805E-04	9.805E-04	9.804E-04	9.804E-04	9.804E-04	9.803E-04	9.803E-04

NI 63	1.096E-01	1.079E-01	1.063E-01	1.047E-01	1.024E-01	9.861E-02	9.496E-02	9.145E-02	8.807E-02	8.481E-02
ZN 65	3.028E-06	3.802E-07	4.760E-08	5.978E-09	2.652E-10	1.478E-12	8.232E-15	4.573E-17	2.548E-19	1.420E-21
SE 79	9.790E-03	9.790E-03	9.790E-03	9.790E-03	9.789E-03	9.789E-03	9.788E-03	9.788E-03	9.787E-03	9.787E-03
KR 85	7.958E+01	6.994E+01	6.145E+01	5.400E+01	4.447E+01	3.219E+01	2.330E+01	1.686E+01	1.220E+01	8.833E+00
RB 87	4.213E-07	4.213E-07	4.213E-07	4.213E-07	4.213E-07	4.213E-07	4.213E-07	4.213E-07	4.213E-07	4.213E-07
SR 89	4.117E-26	1.831E-30	8.038E-35	3.577E-39	1.047E-45	1.363E-56	1.775E-67	2.281E-78	2.970E-89	0.000E+00
SR 90	7.382E+02	7.039E+02	6.712E+02	6.400E+02	5.959E+02	5.290E+02	4.697E+02	4.170E+02	3.702E+02	3.286E+02
Y 90	7.384E+02	7.041E+02	6.713E+02	6.401E+02	5.960E+02	5.292E+02	4.698E+02	4.171E+02	3.703E+02	3.287E+02
Y 91	4.699E-22	8.242E-26	1.429E-29	2.505E-33	5.751E-39	2.315E-48	9.322E-58	3.708E-67	1.493E-76	6.010E-86
ZR 93	3.421E-02	3.421E-02	3.421E-02	3.421E-02	3.421E-02	3.421E-02	3.421E-02	3.421E-02	3.421E-02	3.421E-02
ZR 95	7.665E-20	2.818E-23	1.025E-26	3.766E-30	2.626E-35	6.731E-44	1.725E-52	4.374E-61	1.121E-69	2.873E-78
NB 93M	1.791E-02	1.933E-02	2.061E-02	2.176E-02	2.328E-02	2.535E-02	2.696E-02	2.821E-02	2.917E-02	2.992E-02
NB 94	3.037E-03	3.037E-03	3.037E-03	3.037E-03	3.036E-03	3.036E-03	3.035E-03	3.035E-03	3.034E-03	3.034E-03
NB 95	1.702E-19	6.255E-23	2.275E-26	8.362E-30	5.831E-35	1.494E-43	3.830E-52	9.710E-61	2.489E-69	6.379E-78
NB 95M	5.686E-22	2.091E-25	7.601E-29	2.795E-32	1.948E-37	4.993E-46	1.279E-54	3.244E-63	8.316E-72	2.132E-80
MO 93	7.496E-05	7.493E-05	7.490E-05	7.487E-05	7.483E-05	7.475E-05	7.468E-05	7.461E-05	7.453E-05	7.446E-05
TC 99	9.932E-02	9.932E-02	9.932E-02	9.932E-02	9.932E-02	9.931E-02	9.931E-02	9.931E-02	9.931E-02	9.931E-02
RU103	4.028E-35	1.026E-40	2.565E-46	6.531E-52	2.607E-60	2.649E-74	2.691E-88	0.000E+00	0.000E+00	0.000E+00
RU106	4.432E-02	1.121E-02	2.832E-03	7.164E-04	9.100E-05	2.924E-06	9.398E-08	3.015E-09	9.688E-11	3.113E-12
RH103M	3.631E-35	9.245E-41	2.313E-46	5.888E-52	2.350E-60	2.388E-74	2.426E-88	0.000E+00	0.000E+00	0.000E+00
RH106	4.432E-02	1.121E-02	2.832E-03	7.164E-04	9.100E-05	2.924E-06	9.398E-08	3.015E-09	9.688E-11	3.113E-12
PD107	9.466E-05	9.466E-05	9.466E-05	9.466E-05	9.466E-05	9.466E-05	9.466E-05	9.466E-05	9.466E-05	9.466E-05
AG110	3.000E-09	3.959E-10	5.212E-11	6.880E-12	3.291E-13	2.077E-15	1.312E-17	8.257E-20	5.213E-22	3.291E-24
AG110M	2.255E-07	2.977E-08	3.919E-09	5.173E-10	2.474E-11	1.562E-13	9.861E-16	6.208E-18	3.919E-20	2.474E-22
AG111	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD113M	5.749E-02	5.228E-02	4.754E-02	4.323E-02	3.749E-02	2.956E-02	2.331E-02	1.838E-02	1.449E-02	1.143E-02
CD113	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD115M	1.713E-33	2.023E-38	2.353E-43	2.779E-48	1.110E-55	5.242E-68	2.474E-80	1.149E-92	0.000E+00	0.000E+00
IN114	1.078E-31	3.927E-36	1.411E-40	5.147E-45	1.118E-51	8.845E-63	7.001E-74	5.464E-85	4.325E-96	0.000E+00
IN114M	1.126E-31	4.104E-36	1.476E-40	5.379E-45	1.168E-51	9.242E-63	7.316E-74	5.710E-85	4.519E-96	0.000E+00
IN115M	1.203E-37	1.421E-42	1.652E-47	1.951E-52	7.797E-60	3.680E-72	1.737E-84	8.070E-97	0.000E+00	0.000E+00
SN119M	2.527E-04	3.203E-05	4.051E-06	5.137E-07	2.312E-08	1.321E-10	7.540E-13	4.293E-15	2.451E-17	1.400E-19
SN121M	5.102E-02	4.962E-02	4.826E-02	4.694E-02	4.503E-02	4.201E-02	3.920E-02	3.657E-02	3.412E-02	3.183E-02

SN123	9.993E-11	1.988E-12	3.933E-14	7.825E-16	2.183E-18	1.212E-22	6.729E-27	3.716E-31	2.063E-35	1.145E-39
SN125	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SN126	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02
SB124	1.097E-25	2.453E-29	5.421E-33	1.212E-36	4.006E-42	2.959E-51	2.187E-60	1.597E-69	1.181E-78	8.723E-88
SB125	8.772E+00	5.320E+00	3.224E+00	1.955E+00	9.227E-01	2.641E-01	7.558E-02	2.162E-02	6.187E-03	1.771E-03
SB126	1.487E-03	1.487E-03	1.487E-03	1.487E-03	1.487E-03	1.486E-03	1.486E-03	1.486E-03	1.486E-03	1.486E-03
SB126M	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02	1.062E-02
TE123M	3.674E-16	5.357E-18	7.765E-20	1.132E-21	1.982E-24	5.058E-29	1.291E-33	3.276E-38	8.361E-43	2.134E-47
TE125M	2.141E+00	1.298E+00	7.868E-01	4.772E-01	2.251E-01	6.444E-02	1.844E-02	5.275E-03	1.510E-03	4.321E-04
TE127	4.383E-12	4.224E-14	4.046E-16	3.900E-18	3.667E-21	3.323E-26	3.012E-31	2.712E-36	2.458E-41	2.228E-46
TE127M	4.475E-12	4.313E-14	4.131E-16	3.981E-18	3.744E-21	3.393E-26	3.075E-31	2.769E-36	2.510E-41	2.274E-46
TE129	1.772E-42	5.107E-49	1.442E-55	4.155E-62	6.296E-72	2.750E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE129M	2.722E-42	7.845E-49	2.215E-55	6.383E-62	9.673E-72	4.225E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I129	4.443E-04	4.443E-04	4.443E-04	4.443E-04	4.443E-04	4.443E-04	4.443E-04	4.443E-04	4.443E-04	4.443E-04
I131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE131M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE133	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS134	1.033E+00	5.277E-01	2.693E-01	1.375E-01	5.015E-02	9.342E-03	1.740E-03	3.238E-04	6.032E-05	1.124E-05
CS135	1.016E-02	1.016E-02	1.016E-02	1.016E-02	1.016E-02	1.016E-02	1.016E-02	1.016E-02	1.016E-02	1.016E-02
CS136	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS137	7.080E+02	6.760E+02	6.455E+02	6.163E+02	5.750E+02	5.123E+02	4.564E+02	4.066E+02	3.623E+02	3.227E+02
BA136M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA137M	6.697E+02	6.395E+02	6.106E+02	5.830E+02	5.440E+02	4.846E+02	4.318E+02	3.847E+02	3.427E+02	3.053E+02
BA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE141	2.012E-42	3.503E-49	5.971E-56	1.040E-62	7.393E-73	9.153E-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE142	2.815E-07	2.815E-07	2.815E-07	2.815E-07	2.815E-07	2.815E-07	2.815E-07	2.815E-07	2.815E-07	2.815E-07
CE144	5.167E-02	8.713E-03	1.466E-03	2.471E-04	1.707E-05	1.989E-07	2.316E-09	2.692E-11	3.136E-13	3.652E-15
PR143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR144	5.167E-02	8.713E-03	1.466E-03	2.472E-04	1.707E-05	1.989E-07	2.317E-09	2.692E-11	3.136E-13	3.653E-15
PR144M	6.200E-04	1.046E-04	1.759E-05	2.966E-06	2.049E-07	2.386E-09	2.780E-11	3.230E-13	3.763E-15	4.383E-17
ND144	1.114E-11	1.114E-11	1.114E-11	1.114E-11	1.114E-11	1.114E-11	1.114E-11	1.114E-11	1.114E-11	1.114E-11
ND147	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

PM145	8.394E-04	7.762E-04	7.177E-04	6.637E-04	5.901E-04	4.852E-04	3.989E-04	3.280E-04	2.696E-04	2.217E-04
PM147	5.632E+01	3.322E+01	1.958E+01	1.154E+01	5.225E+00	1.394E+00	3.722E-01	9.927E-02	2.649E-02	7.071E-03
PM148M	5.258E-35	2.509E-40	1.177E-45	5.617E-51	5.757E-59	2.815E-72	1.377E-85	6.621E-99	0.000E+00	0.000E+00
PM148	2.961E-36	1.413E-41	6.630E-47	3.164E-52	3.242E-60	1.586E-73	7.754E-87	0.000E+00	0.000E+00	0.000E+00
SM145	2.919E-07	6.593E-08	1.486E-08	3.355E-09	3.593E-10	8.689E-12	2.101E-13	5.071E-15	1.226E-16	2.966E-18
SM147	8.512E-08	8.569E-08	8.602E-08	8.622E-08	8.638E-08	8.647E-08	8.649E-08	8.650E-08	8.650E-08	8.650E-08
SM151	7.374E+00	7.262E+00	7.150E+00	7.041E+00	6.880E+00	6.620E+00	6.370E+00	6.129E+00	5.898E+00	5.675E+00
EU152	1.406E-01	1.270E-01	1.147E-01	1.036E-01	8.889E-02	6.890E-02	5.340E-02	4.139E-02	3.208E-02	2.486E-02
EU154	1.366E+00	1.163E+00	9.893E-01	8.422E-01	6.612E-01	4.419E-01	2.954E-01	1.974E-01	1.319E-01	8.817E-02
EU155	1.903E+00	1.439E+00	1.089E+00	8.229E-01	5.410E-01	2.690E-01	1.337E-01	6.647E-02	3.305E-02	1.643E-02
EU156	2.707E-97	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	3.324E-07	4.108E-08	5.063E-09	6.257E-10	2.712E-11	1.452E-13	7.773E-16	4.150E-18	2.222E-20	1.190E-22
TB160	1.608E-22	1.469E-25	1.329E-28	1.214E-31	3.320E-36	8.293E-44	2.071E-51	5.124E-59	1.280E-66	3.197E-74
TL206	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15	6.280E-15
TL207	1.234E-01	1.348E-01	1.454E-01	1.554E-01	1.692E-01	1.894E-01	2.067E-01	2.215E-01	2.341E-01	2.448E-01
TL208	2.838E+00	2.795E+00	2.748E+00	2.700E+00	2.625E+00	2.504E+00	2.390E+00	2.281E+00	2.176E+00	2.077E+00
PB210	1.876E-06	2.292E-06	2.745E-06	3.234E-06	4.028E-06	5.501E-06	7.140E-06	8.924E-06	1.083E-05	1.285E-05
PB211	1.238E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01
PB212	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00
BI211	1.238E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01
BI212	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00
PO212	5.061E+00	4.985E+00	4.900E+00	4.814E+00	4.680E+00	4.465E+00	4.261E+00	4.067E+00	3.881E+00	3.704E+00
PO215	1.238E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01
PO216	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00
RN219	1.238E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01
RN220	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00
FR223	1.705E-03	1.861E-03	2.008E-03	2.146E-03	2.337E-03	2.617E-03	2.856E-03	3.060E-03	3.233E-03	3.381E-03
RA223	1.238E-01	1.351E-01	1.458E-01	1.558E-01	1.697E-01	1.900E-01	2.073E-01	2.221E-01	2.347E-01	2.455E-01
RA224	7.900E+00	7.780E+00	7.648E+00	7.513E+00	7.305E+00	6.968E+00	6.651E+00	6.347E+00	6.057E+00	5.781E+00
RA226	8.267E-06	9.299E-06	1.034E-05	1.137E-05	1.294E-05	1.555E-05	1.818E-05	2.084E-05	2.350E-05	2.618E-05
RA228	1.350E-01	1.392E-01	1.426E-01	1.454E-01	1.486E-01	1.522E-01	1.543E-01	1.556E-01	1.563E-01	1.568E-01
AC227	1.235E-01	1.349E-01	1.455E-01	1.555E-01	1.693E-01	1.896E-01	2.069E-01	2.217E-01	2.343E-01	2.450E-01
TH227	1.221E-01	1.333E-01	1.438E-01	1.537E-01	1.673E-01	1.874E-01	2.045E-01	2.191E-01	2.315E-01	2.421E-01

TH228	7.883E+00	7.760E+00	7.628E+00	7.494E+00	7.292E+00	6.962E+00	6.645E+00	6.342E+00	6.052E+00	5.776E+00
TH229	4.837E-02	5.437E-02	6.037E-02	6.637E-02	7.537E-02	9.035E-02	1.053E-01	1.203E-01	1.353E-01	1.502E-01
TH230	1.199E-03	1.203E-03	1.207E-03	1.211E-03	1.217E-03	1.227E-03	1.238E-03	1.248E-03	1.258E-03	1.268E-03
TH231	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06
TH232	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01	1.575E-01
TH234	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07
PA231	3.074E-01	3.074E-01	3.074E-01	3.074E-01	3.073E-01	3.073E-01	3.073E-01	3.072E-01	3.072E-01	3.072E-01
PA233	2.545E-08	2.566E-08	2.588E-08	2.612E-08	2.650E-08	2.719E-08	2.794E-08	2.872E-08	2.954E-08	3.038E-08
PA234M	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07
PA234	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10	4.536E-10
U232	7.588E+00	7.443E+00	7.301E+00	7.162E+00	6.958E+00	6.631E+00	6.320E+00	6.022E+00	5.739E+00	5.470E+00
U233	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01	3.182E+01
U234	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01	2.275E-01
U235	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06	1.653E-06
U236	4.015E-07	4.015E-07	4.015E-07	4.015E-07	4.015E-07	4.016E-07	4.016E-07	4.016E-07	4.017E-07	4.017E-07
U237	2.194E-09	1.993E-09	1.810E-09	1.644E-09	1.423E-09	1.118E-09	8.791E-10	6.910E-10	5.432E-10	4.270E-10
U238	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07	3.489E-07
NP237	2.545E-08	2.566E-08	2.588E-08	2.612E-08	2.650E-08	2.719E-08	2.794E-08	2.872E-08	2.954E-08	3.038E-08
PU236	1.226E-11	7.539E-12	4.635E-12	2.852E-12	1.376E-12	4.094E-13	1.227E-13	3.765E-14	1.245E-14	4.977E-15
PU237	1.819E-41	2.759E-46	4.121E-51	6.251E-56	3.636E-63	3.208E-75	2.830E-87	2.459E-99	0.000E+00	0.000E+00
PU238	2.000E-05	1.969E-05	1.938E-05	1.908E-05	1.864E-05	1.793E-05	1.725E-05	1.659E-05	1.596E-05	1.535E-05
PU239	9.138E-04	9.137E-04	9.137E-04	9.136E-04	9.135E-04	9.134E-04	9.133E-04	9.131E-04	9.130E-04	9.129E-04
PU240	2.166E-04	2.166E-04	2.165E-04	2.165E-04	2.164E-04	2.163E-04	2.162E-04	2.161E-04	2.160E-04	2.158E-04
PU241	8.943E-03	8.123E-03	7.377E-03	6.700E-03	5.799E-03	4.558E-03	3.583E-03	2.817E-03	2.214E-03	1.741E-03
PU242	1.994E-08	1.994E-08	1.994E-08	1.994E-08	1.995E-08	1.995E-08	1.995E-08	1.995E-08	1.995E-08	1.995E-08
PU244	3.242E-17	3.242E-17	3.242E-17	3.242E-17	3.242E-17	3.242E-17	3.242E-17	3.242E-17	3.242E-17	3.242E-17
AM241	3.073E-04	3.336E-04	3.574E-04	3.787E-04	4.069E-04	4.448E-04	4.736E-04	4.952E-04	5.112E-04	5.229E-04
AM242M	3.592E-07	3.559E-07	3.527E-07	3.495E-07	3.447E-07	3.370E-07	3.294E-07	3.220E-07	3.147E-07	3.076E-07
AM242	3.574E-07	3.542E-07	3.509E-07	3.478E-07	3.430E-07	3.353E-07	3.277E-07	3.203E-07	3.131E-07	3.061E-07
AM243	2.017E-08	2.016E-08	2.016E-08	2.016E-08	2.015E-08	2.014E-08	2.013E-08	2.012E-08	2.011E-08	2.010E-08
CM242	2.962E-07	2.934E-07	2.908E-07	2.881E-07	2.843E-07	2.774E-07	2.712E-07	2.650E-07	2.591E-07	2.532E-07
CM243	2.034E-08	1.937E-08	1.845E-08	1.758E-08	1.634E-08	1.447E-08	1.281E-08	1.135E-08	1.005E-08	8.897E-09
CM244	1.821E-07	1.687E-07	1.562E-07	1.447E-07	1.290E-07	1.065E-07	8.799E-08	7.266E-08	6.001E-08	4.956E-08

CM245	3.204E-12	3.203E-12	3.203E-12	3.202E-12	3.201E-12	3.200E-12	3.199E-12	3.197E-12	3.196E-12	3.195E-12
CM246	6.253E-14	6.251E-14	6.249E-14	6.248E-14	6.245E-14	6.240E-14	6.236E-14	6.231E-14	6.227E-14	6.222E-14
CM247	2.116E-20	2.116E-20	2.116E-20	2.116E-20	2.116E-20	2.116E-20	2.116E-20	2.116E-20	2.116E-20	2.116E-20
SUBTOTAL	3.120E+03	2.948E+03	2.795E+03	2.656E+03	2.466E+03	2.189E+03	1.947E+03	1.735E+03	1.548E+03	1.381E+03
AP+ACT+FP	3.121E+03	2.949E+03	2.795E+03	2.656E+03	2.467E+03	2.190E+03	1.948E+03	1.736E+03	1.549E+03	1.383E+03

Table 2-5F. Isotopic Activity Concentrations in Curies for a single LWBR Reflector Module (TYPE V).

Information: Units: CURIES
Burnup: MWd (max)
Burnup: MWd/MTHM
BOL U-233: 0 grams U-233 per module
BOL U-234: 0 grams U-234 per module
BOL U-235: 0 grams U-235 per module
BOL U-236: 0 grams U-236 per module
BOL U-238: 0 grams U-238 per module
BOL Th-232: 1047547.00 grams Th-232 per module
Fuel Meat: ThO₂ (Thoria)
Fuel Enrichment: 0.00 wt% U-233 at BOL
Clad: Zircaloy-4

DECAY DATES										
ISOTOPE	01-Jul-96	01-Jul-98	01-Jul-00	01-Jul-02	01-Jul-05	01-Jul-10	01-Jul-15	01-Jul-20	01-Jul-25	01-Jul-30
H 3	1.607E+00	1.436E+00	1.283E+00	1.147E+00	9.697E-01	7.324E-01	5.531E-01	4.177E-01	3.155E-01	2.383E-01
BE 10	3.807E-08	3.807E-08	3.807E-08	3.807E-08	3.807E-08	3.807E-08	3.807E-08	3.807E-08	3.807E-08	3.807E-08
C 14	2.623E-02	2.623E-02	2.622E-02	2.622E-02	2.620E-02	2.619E-02	2.617E-02	2.616E-02	2.614E-02	2.613E-02
CL 36	3.959E-07	3.959E-07	3.959E-07	3.959E-07	3.959E-07	3.958E-07	3.958E-07	3.958E-07	3.958E-07	3.958E-07
CR 51	9.027E-53	1.059E-60	1.211E-68	1.420E-76	1.757E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
MN 54	3.195E-05	6.328E-06	1.251E-06	2.477E-07	2.178E-08	3.794E-10	6.609E-12	1.149E-13	2.001E-15	3.486E-17
FE 55	4.078E-01	2.394E-01	1.404E-01	8.241E-02	3.703E-02	9.770E-03	2.576E-03	6.789E-04	1.790E-04	4.722E-05
FE 59	3.952E-34	5.168E-39	6.658E-44	8.707E-49	4.056E-56	2.472E-68	1.506E-80	9.042E-93	0.000E+00	0.000E+00

CO 60	5.482E+00	4.214E+00	3.239E+00	2.490E+00	1.678E+00	8.692E-01	4.505E-01	2.333E-01	1.208E-01	6.263E-02
NI 59	7.139E-04	7.138E-04	7.138E-04	7.138E-04	7.138E-04	7.137E-04	7.137E-04	7.137E-04	7.137E-04	7.137E-04
NI 63	7.979E-02	7.855E-02	7.739E-02	7.622E-02	7.455E-02	7.179E-02	6.913E-02	6.658E-02	6.411E-02	6.174E-02
ZN 65	2.204E-06	2.768E-07	3.465E-08	4.352E-09	1.931E-10	1.076E-12	5.993E-15	3.329E-17	1.855E-19	1.034E-21
SE 79	7.127E-03	7.127E-03	7.127E-03	7.127E-03	7.126E-03	7.126E-03	7.126E-03	7.126E-03	7.125E-03	7.125E-03
KR 85	5.793E+01	5.092E+01	4.474E+01	3.931E+01	3.237E+01	2.343E+01	1.696E+01	1.227E+01	8.882E+00	6.430E+00
RB 87	3.067E-07	3.067E-07	3.067E-07	3.067E-07	3.067E-07	3.067E-07	3.067E-07	3.067E-07	3.067E-07	3.067E-07
SR 89	2.997E-26	1.333E-30	5.852E-35	2.604E-39	7.622E-46	9.923E-57	1.292E-67	1.661E-78	2.162E-89	0.000E+00
SR 90	5.374E+02	5.124E+02	4.886E+02	4.659E+02	4.338E+02	3.851E+02	3.419E+02	3.036E+02	2.695E+02	2.392E+02
Y 90	5.376E+02	5.126E+02	4.887E+02	4.660E+02	4.339E+02	3.853E+02	3.420E+02	3.036E+02	2.696E+02	2.393E+02
Y 91	3.421E-22	6.000E-26	1.040E-29	1.824E-33	4.187E-39	1.685E-48	6.786E-58	2.699E-67	1.087E-76	4.375E-86
ZR 93	2.490E-02	2.490E-02	2.490E-02	2.490E-02	2.490E-02	2.490E-02	2.490E-02	2.490E-02	2.490E-02	2.490E-02
ZR 95	5.580E-20	2.052E-23	7.462E-27	2.742E-30	1.912E-35	4.900E-44	1.256E-52	3.184E-61	8.161E-70	2.092E-78
NB 93M	1.304E-02	1.407E-02	1.500E-02	1.584E-02	1.695E-02	1.845E-02	1.963E-02	2.054E-02	2.124E-02	2.178E-02
NB 94	2.211E-03	2.211E-03	2.211E-03	2.211E-03	2.210E-03	2.210E-03	2.209E-03	2.209E-03	2.209E-03	2.209E-03
NB 95	1.239E-19	4.554E-23	1.656E-26	6.088E-30	4.245E-35	1.088E-43	2.788E-52	7.069E-61	1.812E-69	4.644E-78
NB 95M	4.139E-22	1.522E-25	5.534E-29	2.035E-32	1.418E-37	3.635E-46	9.311E-55	2.362E-63	6.054E-72	1.552E-80
MO 93	5.457E-05	5.455E-05	5.453E-05	5.451E-05	5.448E-05	5.442E-05	5.437E-05	5.432E-05	5.426E-05	5.421E-05
TC 99	7.230E-02	7.230E-02	7.230E-02	7.230E-02	7.230E-02	7.230E-02	7.230E-02	7.230E-02	7.230E-02	7.230E-02
RU103	2.932E-35	7.469E-41	1.867E-46	4.755E-52	1.898E-60	1.928E-74	1.959E-88	0.000E+00	0.000E+00	0.000E+00
RU106	3.226E-02	8.161E-03	2.062E-03	5.215E-04	6.625E-05	2.129E-06	6.842E-08	2.195E-09	7.053E-11	2.266E-12
RH103M	2.643E-35	6.730E-41	1.684E-46	4.286E-52	1.711E-60	1.738E-74	1.766E-88	0.000E+00	0.000E+00	0.000E+00
RH106	3.226E-02	8.161E-03	2.062E-03	5.215E-04	6.625E-05	2.129E-06	6.842E-08	2.195E-09	7.053E-11	2.266E-12
PD107	6.891E-05	6.891E-05	6.891E-05	6.891E-05	6.891E-05	6.891E-05	6.891E-05	6.891E-05	6.891E-05	6.891E-05
AG110	2.184E-09	2.882E-10	3.794E-11	5.009E-12	2.396E-13	1.512E-15	9.551E-18	6.011E-20	3.795E-22	2.396E-24
AG110M	1.642E-07	2.167E-08	2.853E-09	3.766E-10	1.801E-11	1.137E-13	7.179E-16	4.519E-18	2.853E-20	1.801E-22
AG111	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD113M	4.185E-02	3.806E-02	3.461E-02	3.147E-02	2.729E-02	2.152E-02	1.697E-02	1.338E-02	1.055E-02	8.321E-03
CD113	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CD115M	1.247E-33	1.473E-38	1.713E-43	2.023E-48	8.081E-56	3.816E-68	1.801E-80	8.365E-93	0.000E+00	0.000E+00
IN114	7.848E-32	2.859E-36	1.027E-40	3.747E-45	8.139E-52	6.439E-63	5.097E-74	3.978E-85	3.149E-96	0.000E+00
IN114M	8.197E-32	2.988E-36	1.075E-40	3.916E-45	8.503E-52	6.728E-63	5.326E-74	4.157E-85	3.290E-96	0.000E+00
IN115M	8.758E-38	1.034E-42	1.203E-47	1.420E-52	5.676E-60	2.679E-72	1.265E-84	5.875E-97	0.000E+00	0.000E+00

SN119M	1.840E-04	2.332E-05	2.949E-06	3.740E-07	1.683E-08	9.617E-11	5.489E-13	3.125E-15	1.784E-17	1.019E-19
SN121M	3.714E-02	3.612E-02	3.513E-02	3.417E-02	3.278E-02	3.058E-02	2.854E-02	2.662E-02	2.484E-02	2.317E-02
SN123	7.275E-11	1.447E-12	2.863E-14	5.697E-16	1.589E-18	8.823E-23	4.899E-27	2.705E-31	1.502E-35	8.336E-40
SN125	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SN126	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03
SB124	7.986E-26	1.786E-29	3.946E-33	8.823E-37	2.916E-42	2.154E-51	1.592E-60	1.163E-69	8.598E-79	6.350E-88
SB125	6.386E+00	3.873E+00	2.347E+00	1.423E+00	6.717E-01	1.923E-01	5.502E-02	1.574E-02	4.504E-03	1.289E-03
SB126	1.083E-03	1.083E-03	1.083E-03	1.083E-03	1.083E-03	1.082E-03	1.082E-03	1.082E-03	1.082E-03	1.082E-03
SB126M	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03	7.731E-03
TE123M	2.675E-16	3.900E-18	5.653E-20	8.241E-22	1.443E-24	3.682E-29	9.398E-34	2.385E-38	6.087E-43	1.554E-47
TE125M	1.559E+00	9.449E-01	5.728E-01	3.474E-01	1.639E-01	4.691E-02	1.342E-02	3.840E-03	1.099E-03	3.146E-04
TE127	3.191E-12	3.075E-14	2.945E-16	2.839E-18	2.670E-21	2.419E-26	2.193E-31	1.974E-36	1.789E-41	1.622E-46
TE127M	3.258E-12	3.140E-14	3.007E-16	2.898E-18	2.726E-21	2.470E-26	2.239E-31	2.016E-36	1.827E-41	1.655E-46
TE129	1.290E-42	3.718E-49	1.050E-55	3.025E-62	4.583E-72	2.002E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TE129M	1.982E-42	5.711E-49	1.613E-55	4.647E-62	7.042E-72	3.076E-88	0.000E+00	0.000E+00	0.000E+00	0.000E+00
I129	3.235E-04	3.235E-04	3.235E-04	3.235E-04	3.235E-04	3.235E-04	3.235E-04	3.235E-04	3.235E-04	3.235E-04
I131	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE131M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
XE133	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS134	7.520E-01	3.842E-01	1.961E-01	1.001E-01	3.651E-02	6.801E-03	1.267E-03	2.357E-04	4.391E-05	8.183E-06
CS135	7.396E-03	7.396E-03	7.396E-03	7.396E-03	7.396E-03	7.396E-03	7.396E-03	7.396E-03	7.396E-03	7.396E-03
CS136	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CS137	5.154E+02	4.921E+02	4.699E+02	4.487E+02	4.186E+02	3.730E+02	3.323E+02	2.960E+02	2.638E+02	2.349E+02
BA136M	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
BA137M	4.875E+02	4.656E+02	4.445E+02	4.244E+02	3.960E+02	3.528E+02	3.144E+02	2.801E+02	2.495E+02	2.223E+02
BA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LA140	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE141	1.465E-42	2.550E-49	4.347E-56	7.571E-63	5.382E-73	6.663E-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE142	2.049E-07	2.049E-07	2.049E-07	2.049E-07	2.049E-07	2.049E-07	2.049E-07	2.049E-07	2.049E-07	2.049E-07
CE144	3.762E-02	6.343E-03	1.067E-03	1.799E-04	1.243E-05	1.448E-07	1.686E-09	1.960E-11	2.283E-13	2.659E-15
PR143	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PR144	3.762E-02	6.343E-03	1.067E-03	1.800E-04	1.243E-05	1.448E-07	1.687E-09	1.960E-11	2.283E-13	2.659E-15
PR144M	4.514E-04	7.615E-05	1.281E-05	2.159E-06	1.492E-07	1.737E-09	2.024E-11	2.351E-13	2.739E-15	3.191E-17

ND144	8.110E-12	8.110E-12	8.110E-12	8.110E-12	8.110E-12	8.110E-12	8.110E-12	8.110E-12	8.110E-12	8.110E-12
ND147	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PM145	6.111E-04	5.651E-04	5.225E-04	4.832E-04	4.296E-04	3.532E-04	2.904E-04	2.388E-04	1.963E-04	1.614E-04
PM147	4.100E+01	2.418E+01	1.425E+01	8.401E+00	3.804E+00	1.015E+00	2.710E-01	7.227E-02	1.928E-02	5.148E-03
PM148M	3.828E-35	1.827E-40	8.569E-46	4.089E-51	4.191E-59	2.049E-72	1.002E-85	4.820E-99	0.000E+00	0.000E+00
PM148	2.156E-36	1.029E-41	4.827E-47	2.303E-52	2.360E-60	1.155E-73	5.645E-87	0.000E+00	0.000E+00	0.000E+00
SM145	2.125E-07	4.800E-08	1.082E-08	2.442E-09	2.616E-10	6.326E-12	1.530E-13	3.692E-15	8.925E-17	2.159E-18
SM147	6.197E-08	6.238E-08	6.262E-08	6.277E-08	6.288E-08	6.295E-08	6.296E-08	6.297E-08	6.297E-08	6.297E-08
SM151	5.368E+00	5.287E+00	5.205E+00	5.126E+00	5.009E+00	4.819E+00	4.637E+00	4.462E+00	4.294E+00	4.131E+00
EU152	1.024E-01	9.246E-02	8.350E-02	7.542E-02	6.471E-02	5.016E-02	3.888E-02	3.013E-02	2.335E-02	1.810E-02
EU154	9.944E-01	8.467E-01	7.202E-01	6.131E-01	4.814E-01	3.217E-01	2.151E-01	1.437E-01	9.602E-02	6.419E-02
EU155	1.385E+00	1.048E+00	7.928E-01	5.991E-01	3.938E-01	1.958E-01	9.733E-02	4.839E-02	2.406E-02	1.196E-02
EU156	1.971E-97	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
GD153	2.420E-07	2.991E-08	3.686E-09	4.555E-10	1.974E-11	1.057E-13	5.659E-16	3.021E-18	1.618E-20	8.663E-23
TB160	1.171E-22	1.069E-25	9.675E-29	8.838E-32	2.417E-36	6.037E-44	1.508E-51	3.730E-59	9.318E-67	2.327E-74
TL206	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15	4.572E-15
TL207	8.984E-02	9.813E-02	1.059E-01	1.131E-01	1.232E-01	1.379E-01	1.505E-01	1.613E-01	1.704E-01	1.782E-01
TL208	2.066E+00	2.035E+00	2.001E+00	1.966E+00	1.911E+00	1.823E+00	1.740E+00	1.661E+00	1.584E+00	1.512E+00
PB210	1.366E-06	1.669E-06	1.998E-06	2.354E-06	2.932E-06	4.005E-06	5.198E-06	6.497E-06	7.884E-06	9.355E-06
PB211	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
PB212	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
BI211	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
BI212	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
PO212	3.684E+00	3.629E+00	3.567E+00	3.505E+00	3.407E+00	3.251E+00	3.102E+00	2.961E+00	2.825E+00	2.697E+00
PO215	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
PO216	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
RN219	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
RN220	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
FR223	1.241E-03	1.355E-03	1.462E-03	1.562E-03	1.701E-03	1.905E-03	2.079E-03	2.228E-03	2.354E-03	2.461E-03
RA223	9.013E-02	9.835E-02	1.061E-01	1.134E-01	1.235E-01	1.383E-01	1.509E-01	1.617E-01	1.709E-01	1.787E-01
RA224	5.751E+00	5.664E+00	5.568E+00	5.469E+00	5.318E+00	5.073E+00	4.842E+00	4.621E+00	4.409E+00	4.209E+00
RA226	6.018E-06	6.770E-06	7.528E-06	8.277E-06	9.420E-06	1.132E-05	1.324E-05	1.517E-05	1.711E-05	1.906E-05
RA228	9.828E-02	1.013E-01	1.038E-01	1.059E-01	1.082E-01	1.108E-01	1.123E-01	1.133E-01	1.138E-01	1.142E-01

AC227	8.991E-02	9.821E-02	1.059E-01	1.132E-01	1.233E-01	1.380E-01	1.506E-01	1.614E-01	1.706E-01	1.784E-01
TH227	8.889E-02	9.704E-02	1.047E-01	1.119E-01	1.218E-01	1.364E-01	1.489E-01	1.595E-01	1.685E-01	1.762E-01
TH228	5.739E+00	5.649E+00	5.553E+00	5.456E+00	5.309E+00	5.068E+00	4.838E+00	4.617E+00	4.406E+00	4.205E+00
TH229	3.521E-02	3.958E-02	4.395E-02	4.832E-02	5.487E-02	6.577E-02	7.666E-02	8.758E-02	9.850E-02	1.093E-01
TH230	8.729E-04	8.758E-04	8.787E-04	8.816E-04	8.860E-04	8.933E-04	9.013E-04	9.085E-04	9.158E-04	9.231E-04
TH231	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06
TH232	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01	1.147E-01
TH234	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07
PA231	2.238E-01	2.238E-01	2.238E-01	2.238E-01	2.237E-01	2.237E-01	2.237E-01	2.236E-01	2.236E-01	2.236E-01
PA233	1.853E-08	1.868E-08	1.884E-08	1.902E-08	1.929E-08	1.979E-08	2.034E-08	2.091E-08	2.151E-08	2.212E-08
PA234M	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07
PA234	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10	3.302E-10
U232	5.524E+00	5.419E+00	5.315E+00	5.214E+00	5.065E+00	4.827E+00	4.601E+00	4.384E+00	4.178E+00	3.982E+00
U233	2.316E+01	2.316E+01	2.316E+01	2.316E+01	2.316E+01	2.316E+01	2.316E+01	2.316E+01	2.316E+01	2.316E+01
U234	1.656E-01	1.656E-01	1.656E-01	1.656E-01	1.656E-01	1.656E-01	1.656E-01	1.656E-01	1.656E-01	1.656E-01
U235	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06	1.203E-06
U236	2.923E-07	2.923E-07	2.923E-07	2.923E-07	2.923E-07	2.924E-07	2.924E-07	2.924E-07	2.924E-07	2.924E-07
U237	1.597E-09	1.451E-09	1.318E-09	1.197E-09	1.036E-09	8.139E-10	6.400E-10	5.030E-10	3.954E-10	3.109E-10
U238	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07	2.540E-07
NP237	1.853E-08	1.868E-08	1.884E-08	1.902E-08	1.929E-08	1.979E-08	2.034E-08	2.091E-08	2.151E-08	2.212E-08
PU236	8.925E-12	5.488E-12	3.374E-12	2.076E-12	1.002E-12	2.980E-13	8.933E-14	2.741E-14	9.064E-15	3.623E-15
PU237	1.324E-41	2.009E-46	3.000E-51	4.551E-56	2.647E-63	2.335E-75	2.060E-87	1.790E-99	0.000E+00	0.000E+00
PU238	1.456E-05	1.433E-05	1.411E-05	1.389E-05	1.357E-05	1.305E-05	1.256E-05	1.208E-05	1.162E-05	1.117E-05
PU239	6.652E-04	6.652E-04	6.652E-04	6.651E-04	6.650E-04	6.650E-04	6.649E-04	6.647E-04	6.647E-04	6.646E-04
PU240	1.577E-04	1.577E-04	1.576E-04	1.576E-04	1.575E-04	1.575E-04	1.574E-04	1.573E-04	1.572E-04	1.571E-04
PU241	6.511E-03	5.914E-03	5.370E-03	4.878E-03	4.222E-03	3.318E-03	2.608E-03	2.051E-03	1.612E-03	1.267E-03
PU242	1.452E-08	1.452E-08	1.452E-08	1.452E-08	1.452E-08	1.452E-08	1.452E-08	1.452E-08	1.452E-08	1.452E-08
PU244	2.360E-17	2.360E-17	2.360E-17	2.360E-17	2.360E-17	2.360E-17	2.360E-17	2.360E-17	2.360E-17	2.360E-17
AM241	2.237E-04	2.429E-04	2.602E-04	2.757E-04	2.962E-04	3.238E-04	3.448E-04	3.605E-04	3.722E-04	3.807E-04
AM242M	2.615E-07	2.591E-07	2.568E-07	2.544E-07	2.509E-07	2.453E-07	2.398E-07	2.344E-07	2.291E-07	2.239E-07
AM242	2.602E-07	2.579E-07	2.555E-07	2.532E-07	2.497E-07	2.441E-07	2.386E-07	2.332E-07	2.279E-07	2.228E-07
AM243	1.468E-08	1.468E-08	1.468E-08	1.468E-08	1.467E-08	1.466E-08	1.465E-08	1.465E-08	1.464E-08	1.463E-08
CM242	2.156E-07	2.136E-07	2.117E-07	2.097E-07	2.070E-07	2.019E-07	1.974E-07	1.929E-07	1.886E-07	1.843E-07

CM243	1.481E-08	1.410E-08	1.343E-08	1.280E-08	1.190E-08	1.053E-08	9.326E-09	8.263E-09	7.316E-09	6.477E-09
CM244	1.326E-07	1.228E-07	1.137E-07	1.053E-07	9.391E-08	7.753E-08	6.406E-08	5.290E-08	4.369E-08	3.608E-08
CM245	2.333E-12	2.332E-12	2.332E-12	2.331E-12	2.330E-12	2.330E-12	2.329E-12	2.327E-12	2.327E-12	2.326E-12
CM246	4.552E-14	4.551E-14	4.549E-14	4.549E-14	4.546E-14	4.543E-14	4.540E-14	4.536E-14	4.533E-14	4.530E-14
CM247	1.540E-20	1.540E-20	1.540E-20	1.540E-20	1.540E-20	1.540E-20	1.540E-20	1.540E-20	1.540E-20	1.540E-20
SUBTOTAL	2.272E+03	2.146E+03	2.035E+03	1.933E+03	1.795E+03	1.593E+03	1.418E+03	1.263E+03	1.127E+03	1.006E+03

3.0 TRIGA FUEL TYPES

3.1 Introduction

In general, TRIGA fuel elements consist of uranium-zirconium hydride (UZrH_x) fuel rods with metal cladding (most with aluminum or stainless steel tubes, some with Incoloy). The fuel rod is axially centered in the tube with a graphite moderator slug at each end. Burnable poison discs, if present, are placed in between the fuel rod and the graphite. There is no bonding material between the fuel and cladding. Fixtures are heliarc welded to the top and bottom ends of the cladding encapsulating all of the internal pieces. The bottom end fixtures of the fuel element are designed to guide the fuel elements into the bottom support plate of the reactor core. The top end fixtures provide a grooved end surface that the coupling end of the handling tool can grip. Each fuel element has a permanent serial number engraved on the top end fixture in approximately 0.25-inch numerals. The serial number is unique for each element and can be used to trace the fabrication history of the components within an element.

TRIGA fuel has several unique characteristics, including:

1. Prompt negative temperature coefficient of reactivity; provides the inherent safety and ability to pulse.
2. High fission product retention - experiments have proven that unclad TRIGA fuel material releases less than 10^{-4} of gaseous fission products under postulated accident conditions.
3. No metal/water reactions - the uranium-zirconium hydride fuel of TRIGA reactors exhibits no significant metal-water reactions even when quenched in water from 1200°C .
4. High-temperature strength and ductility of the stainless steel clad TRIGA fuel.

Distinctions among TRIGA fuel elements are typically associated with one of two variables: 1) the specifications for fuel fabrication in use at General Atomics (GA) at time of manufacture and 2) specific parameters of the requestor. Changes in the GA manufacturing process were implemented throughout the TRIGA program to improve reactor power capacity and increase in the useful life of the fuel elements. Requestors would specify the end fixtures required to accommodate their particular grid plate and coolant flow designs.

3.2 Physical Description of Fuel

3.2.1 Uranium Zirconium Hydride Fuel Matrix

The TRIGA fuel fabrication process used by GA in the early 1960s produced solid rods of uranium zirconium hydride with a hydrogen to zirconium ratio of about 1 (UZrH_1). In 1965 GA implemented a major manufacturing change by drilling a 0.25-inch hole through the

uranium zirconium hydride rods to facilitate hydriding. These hollow rods yielded a more uniform hydride content throughout the entire fuel meat matrix. The nominal hydrogen to zirconium atom ratio of 1.7 ($\text{UZrH}_{1.7}$) was fairly consistent throughout the entire fuel matrix. The hole in the hollow rod was filled with a 0.225-inch diameter solid zirconium rod after hydriding had taken place. Limited documentation is publicly available concerning the GA fabrication process. Procedures and specifications identifying details such as fuel meat density, impurity levels, porosity, and hydride gradients are not available at this time.

3.2.2 Standard Stainless Steel Clad Elements

3.2.2.1 Standard Stainless Steel Clad Fuel Moderator Elements

Standard stainless steel clad moderator TRIGA elements homogeneously combine a zirconium hydride moderator with enriched uranium fuel (see Figure 3-1). The uniform hydrogen-to-zirconium atom ratio of 1.7 to 1 is achieved through the use of the hollow rod design. The active fuel section is 1.435 inches in diameter and 15 inches long (composed of three 5-inch long $\text{UZrH}_{1.7}$ pieces) and contains 8.5wt % uranium enriched to 20% in ^{235}U . The nominal ^{235}U content is 39 g. The samarium trioxide burnable poison discs were not used in the standard stainless steel clad elements. Above and below the fuel section, 3.42 inch long graphite slugs act as neutron reflectors.

The standard stainless steel elements were clad with 0.02 inch thick type 304 stainless steel with end fitting closures made by heliarc welding. The ^{235}U content comprises about 1.7% of the weight of the active section. Each element contains 156 g ^{238}U and 2088 g zirconium (nominal values). A plenum gap of at least 0.25 inch is left above the upper section of graphite to accommodate thermal expansion between the fuel-moderator material and the graphite. The overall element measures 28.94 inches with the end fitting design (see Table 3-1).

3.2.2.2 Instrumented Standard Stainless Steel Clad Elements

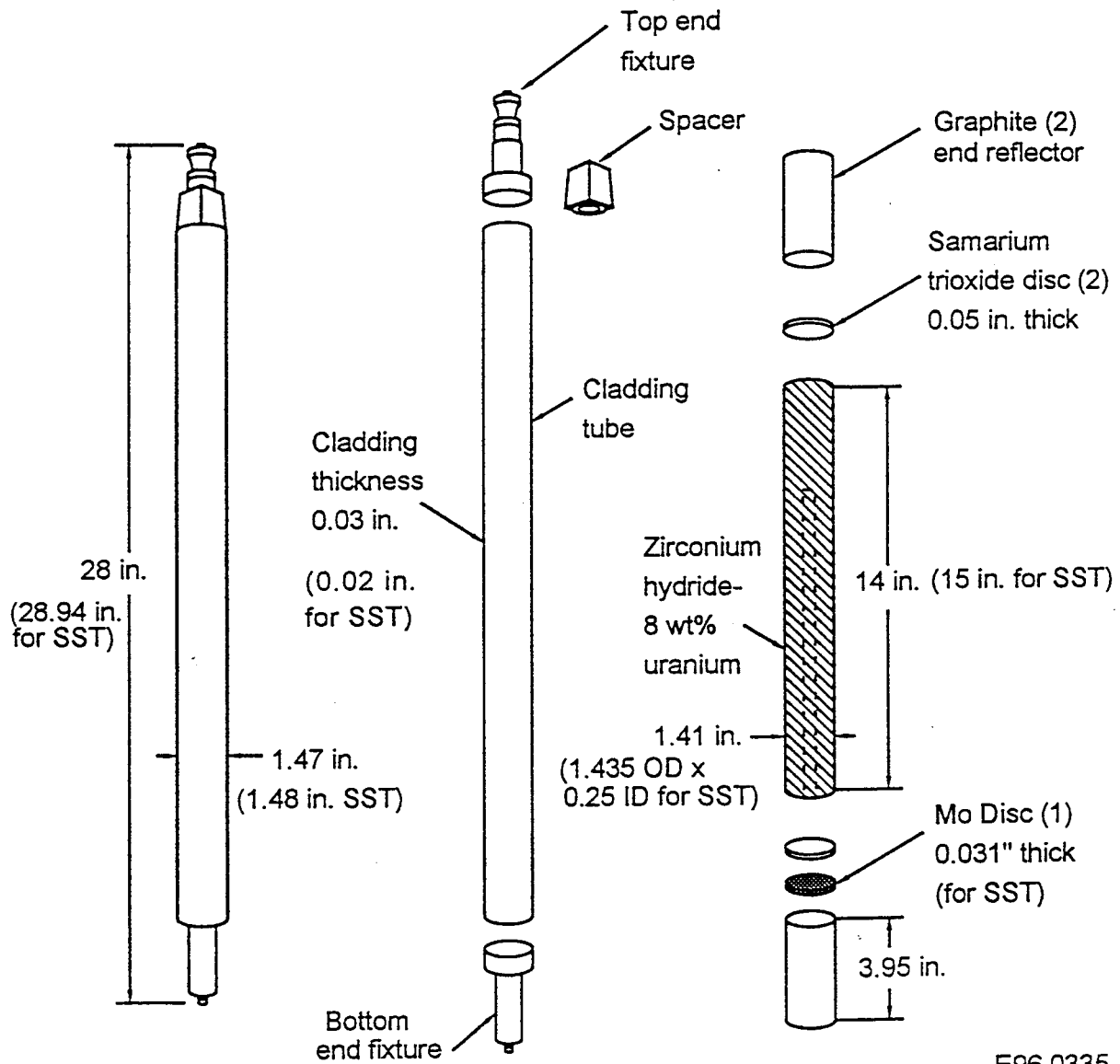
Stainless steel clad instrumented elements were also received from GA. These are similar to the standard stainless steel clad fuel moderator elements describe above, but in addition these elements have three chromel-alumel thermocouples embedded into the fuel meat. The sensing tips are located halfway between the outer radius and the vertical centerline of the fuel section, and at the horizontal center and one inch above and below this position. The thermocouple lead out wires pass through a seal at the upper-end fixture and then through additional tubing to provide a watertight conduit to carry the lead-out wires above the water surface. All other dimensions are identical to the standard stainless steel clad fuel moderator element.

3.2.3 Fuel Follower Control Rod Elements

The Advanced TRIGA reactor also operates with several fuel follower control rod (FFCR) elements to offset the long term effects of fuel burnup. There are three types of FFCRs: a safety rod, a regulating rod, and a shim rod. All three types are basically the same element,

but they each serve a different function within the core. These elements are sealed Type 304 stainless steel tubes 45.0 inches long by 1.35 inches in diameter. The uppermost 6.5 inch section is an air void with the next 15 inches being a solid boron carbide neutron absorber rod. Directly below the neutron absorber is a fuel section consisting of 15 inches of $\text{UZrH}_{1.7}$ fuel. The bottom section of the rod has a 6.5 inch air void. The fuel sections of the FFCR weigh approximately 2000 g with uranium comprising 8.5 wt % of the total mass (20% initial enrichment). Each element is clad with a 0.02 inch thick stainless steel tube. Stainless steel fixtures are attached by heliarc welding to both ends of the tube.

There are three variations on the initial fuel loading for the FFCRs. The first is a standard 20% U-235 enrichment with 8.5 wt % U. The second is the FLIP-LEU-I loading (20% enrichment, 20 wt %). The first and second variations have the same dimensions. The third is the ACPR loading (20% enrichment, 12 wt %).



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Figure 3-1. Standard TRIGA Rod

Table 3-1. Physical Characteristics of the Standard TRIGA Fuel Elements

Characteristics	Al Clad Elements	Standard SST Clad Elements
Element dim., in.	1.47 dia x 28 long	1.478 dia. x 28.94 long
Geometry of fuel meat	Solid rod	Hollow rod
Effective fuel length, in.	1.41 dia x 14 long	1.435 OD x 0.25 ID x 15 long
Plenum gap length	NA	0.25 in.
Fuel meat material	UZrH ₁	UZrH _{1.7}
Nominal ²³⁵ U	36 g	39 g
Nominal ^{Total} U	180 g	195 g
Nominal fuel meat weight	2250 g	2283 g
Total element weight	2.9 kg	3.4 kg
U ppt size	NA	NA
Burnable poisons	Samarium trioxide	None Used
Poison dim., in.	1.42 dia x 0.05 thick	---
Rod-Cladding gap	NA	NA
Cladding	1100F Al	Type 304 SST
Clad thickness	0.03 in.	0.02 in.
Weld filler material	NA	NA
2 End fixtures	140 g	530 g
2 Graphite end reflectors	1.41 dia x 3.95 long each	1.435 dia. x 3.42 long each
Material added to element	None known	0.225 in dia. Zr rod inside hollow fuel rod. Molybdenum disc,* 1.435 in. dia. x 0.031 inches thick

NA = Information is not available at this time.

* located between the fuel meat and the bottom graphite end reflector, ONLY in elements produced after 4/15/71.

** Contradictory information has been identified: some of these parameters may not be correct depending on date of fabrication.

ACPR FFCRs are assembled slightly differently than the standard. The overall length is 66.5 in. and the diameter is 1.5 in. The length of the fuel meat is 14.25 in. (about 5% shorter than the regular ACPR element). This is positioned just below the poison, or neutron absorber, boron carbide that is 15 inches of three segments. The bottom section of the rod is 25 in. of air void. The cladding of these elements is similar to that of the regular element in that the 304-type SST clad, thickness, fabrication methods and insulation gap, and dimple design are all the same.

3.2.4 New Stainless Steel Clad TRIGA

New stainless steel clad TRIGA elements currently being produced by GA (these elements would have been fabricated after April 15, 1971) have a 0.031-inch thick 1.435-inch diameter molybdenum disc between the fuel rod and the bottom graphite plug. All other dimensions are the same as the standard stainless steel clad elements.

3.2.5 Streamline Stainless Steel Clad Elements

The standard streamline element has a 15 inch fuel meat length with a central zirconium rod (the zirconium rod manufacture did not begin until the end of 1964). The graphite reflectors, located at each end of the fuel meat, are different lengths in this assembly. The upper

graphite section is 2.56 inches and the lower graphite is 3.72 inches long. The overall length of the assembly is 29.68 inches and the total diameter is 1.478 inches.

3.2.6 Fuel Life Improvement Program Elements

The Fuel Life Improvement Program (FLIP) was designed to extend the life of the standard TRIGA elements. The first of these FLIP elements is HEU or high enriched uranium. It is 70% U-235 enriched with the standard 8.5 wt % total U. The FLIP element has the central zirconium rod for a Zr/H ratio of 1.6 and is clad in stainless steel. The use of erbium in conjunction with the higher U-235 loadings permits longer core lifetimes than obtainable with the original TRIGA fuel. Erbium enrichment is about 1.48 to 1.6 wt %. All the analyses that have been made on the alloy show that the erbium is dispersed uniformly, creating an erbium hydride, meaning that erbium is fairly stable within the fuel matrix.

The combination of high peak fuel temperatures that occur during a pulse and the increased zirconium-hydride ratio can cause excessive hydrogen pressures in the fuel matrix, which can cause excessive swelling and fuel element deformation. Pulse sizes should be reduced in longer burning cores (i.e., FLIP cores) to account for the effects of hydrogen redistribution. However, this effect is independent of uranium content.

The FLIP-LEU-I is a low enriched FLIP fuel element with 20% U-235 enrichment at 20 wt % and 0.5 wt % of Er. The behavior of the LEU-I and II is indistinguishable from that of the standard 8.5 wt %, and should permit a one-for-one fuel element replacement in the reactor core.

The FLIP-LEU-II is also a low enriched FLIP fuel element with 20% U-235 enrichment at 30 wt % and 0.9 wt % Er.

3.2.7 Annular Core Pulsed Reactor TRIGA Elements

The Annular Core Pulsed Reactor fuel is TRIGA fuel made especially for the ACPR reactor. This fuel has 20% U-235 enrichment and 12 wt % total U. Other dimensions and cladding are similar to the standard stainless steel clad elements. Also called pseudo-standard, this fuel can also be used as partial replacement for standard fuel elements

ACPR cladding is provided with internal dimples to act as spacers ensuring a thermal gap between the fuel meat and the cladding. This gap (375 μ m, 0.015 inch), a built-in thermal barrier, introduces a thermal resistance to control heat flow rates from the fuel immediately after pulsed operation and to prevent film boiling.

ACPR also has its own instrumented elements and its own type of fuel followed control rod (FFCR) that are used in the ACPR reactor.

3.2.8 Aluminum Clad Elements

The aluminum-clad element is the original design from General Atomic. The tubing used

for cladding was 0.03 inch thick type 1100F aluminum. Aluminum-clad TRIGA fuel elements have poorer integrity and robustness, and are more prone to failure during handling. Consequently, they were phased out of use and replaced by stainless steel because of its high durability, comparable resistivity to handling damage, and better burnup statistics.

The overall length of the aluminum clad moderator elements is approximately 28 inches with a 14 inch active fuel section composed of a single solid UZrH rod 1.41 inch in diameter. Reflector rods, located between the end fittings and the poison discs or fuel meat at both ends of the assembly, are made of graphite. The 14 inch fuel rod has 8.0-8.5 wt % uranium enriched to 20% in U-235. The burnable poison disks contained samarium trioxide.

Since 1964, newer aluminum clad elements were produced with 15 inch hollow fuel sections with the zirconium-hydride ratio of ~1.6. The uranium loading and enrichment remained about the same, but the poison disks were discontinued.

Aluminum clad instrumented fuel elements have three chromel-alumel thermocouples embedded in the fuel. The thermocouple wires pass through an aluminum lead-out tube at the top of the element and are otherwise similar to the fuel moderator elements.

3.2.9 Incoloy Clad Elements

The Incoloy clad elements use the Incoloy 800 alloy, also referred to as Alloy 800. The cladding is 0.016 in. thick with outside diameters of 0.54 inch or 1.2 inches. Element length is 30.37 inches. The active fuel section is 22 in. long by 0.51 in. diameter. This fuel section is divided into four 5.5-in. segments, sometimes called pellets, rather than the three 5-inch segments used in the standard element configurations. End fittings may be made of either stainless steel or Incoloy.

The Incoloy clad TRIGA is an HEU fuel that consists of 93% enriched U-235 with approximate 10 wt % total U and 2.8 wt % Er. A LEU variation of Incoloy clad fuel elements is also available enriched to 19.7% U-235, 45 wt % total U and 1.1 wt % Er.

Although the Incoloy clad elements have a zirconium-hydride ratio of 1 to 1.6, the elements do not have a zirconium rod in the center. Graphite reflector rods are also absent in the Incoloy clad elements, replaced by a plenum region that accommodates a 3 in. spring made of Incoloy 800. The spring is there to keep the fuel meat in place and to accommodate axial fuel growth.

Incoloy clad instrumented elements are also used. Chromel-alumel thermocouples are attached to the fuel and wired through a lead-out tube at the top of the element. Other dimensions are comparable to the Incoloy clad fuel moderator elements.

3.2.10 Multiple Element Clusters

For several conversion reactors, TRIGA fuel elements are bundled into “clusters” to better replace plate type fuels. This appears to justify some of the size variations in the Incoloy clad

and “streamline” stainless steel TRIGA elements.

3.3 Packaging

All TRIGA spent nuclear fuel element to be delivered to the Contractor will be contained in packaging described below and in Section J, Attachment J-L.

The INEEL is expected to receive a large number of TRIGA elements during the next 10 years from domestic reactors as well as Foreign Research Reactors (FRR) worldwide.

TRIGA fuels arriving at the INEEL have likely been stored in water for some time, but they will be placed in dry storage within the IFSF upon arrival, pending repackaging for delivery to the Contractor.

Worldwide, TRIGA fuel elements are stored in a variety of different configurations and in a wide range of environmental conditions (i.e., dry vs. wet, clean vs. questionable environments, etc.). Since these conditions are not currently known for the reactors throughout the world, the as stored condition is not available for the entire TRIGA inventory. However, in general, the stainless steel clad fuel elements should be relatively free of corrosion or degradation due to the durability of the stainless steel cladding material.

In order to facilitate TRIGA fuel loading, transfer, and handling, all standard stainless steel or aluminum clad TRIGA fuel under this contract will be packaged in a standard configuration within the Peach Bottom Casks for transfer to the Contractor. This will consist of the following can/bucket/canister configuration:

Can: 5 individual TRIGA SNF elements will be placed in a 5 position standard TRIGA fuel can, CAN-GSF-134-XX, INEEL Drawing 516777 Rev. 0 (currently DRAFT). The pintle used to handle the can is the same as the TRIGA fuel element pintle.

Bucket: Six cans, as described above, will be placed in a Foreign Research Reactor (FRR) TRIGA Bucket, BU-GSF-BEL-XX, as shown on INEEL Drawing 508724 Rev. 3. The bucket is approximately 31” tall and is handled with a locking hook.

Canister: Three buckets, as described above, will be placed in an IFSF Lighter Weight Storage Canister, CAN-GSF-276-XX, as shown on INEEL Drawing 453318 Rev. 3, 4, or 5. Revisions 3, 4, and 5 do not vary in actual configuration or physical characteristics of the canister.

In order to maintain configuration control within the above described Lighter Weight Storage Canister, the following canister gap plug will be utilized:

Canister Gap Plug: A Canister Gap Plug will be placed on top of the upper bucket to fill the remaining space in the canister to prevent any significant shifting of the buckets, and preclude/mitigate safety issues when the cask is placed horizontally on the transport trailer for delivery to the SNFDSP facility. The gap plug will have the same lifting fixture, bottom plate, and outer diameter as the above described TRIGA Buckets. The weight of the gap plug will be kept to the minimum required to provide the necessary structural integrity.

The Lighter Weight Storage Canister will be placed in one of the Peach Bottom Casks, CA-SF-005 or CA-SF-006. In order to maintain the position of within above described Lighter Weight Storage Canister within the larger Peach Bottom Cask (CA-SF-005 or CA-SF-006) internal bore, protect the bore internal surface, and provide additional confinement, the following equipment will be utilized:

Cask Liner and Overpack: The Peach Bottom Casks, CA-SF-005 or CA-SF-006 will have a Liner and Canister Overpack installed as shown on INEEL Drawings 519574, 519575, and 519576, all currently Revision 0.

If deemed necessary to ensure an adequate safety envelope for transporting TRIGA spent nuclear fuel to the Contractor, the Peach Bottom Cask(s) may include the impact limiters to avoid unacceptable damage to the fuel or it's containers in the event of a transportation drop accident.

Each shipment will contain 90 standard stainless and/or aluminum clad TRIGA elements. In addition, once the TRIGA spent nuclear fuel has been unloaded the Contractor, the aforementioned equipment shall be returned to DOE for reuse. This not only serves to reduce waste generation, but also reduces the amount of government furnished equipment that needs to fabricate in support of this campaign.

3.4 As Stored Condition

Generally, the TRIGA fuels should be in very good condition. The container may have degraded badly, but the fuel meat itself is highly stabile and will not degrade under most normal storage conditions (i.e., 30°C in a water or air environment). Zirconium hydride is one of the most chemically, thermally, and radiolytically stable hydrides, particularly in monolithic form. The monolithic hydride is essentially stable in underwater storage. At ambient temperatures, zirconium hydride reacts very slowly with air or water, and is protected from further reaction by the formation of a tenacious, impermeable oxide film. Furthermore at ambient temperatures the hydride is thermodynamically stable compared to the parent elements, and will not lose hydrogen by dissociation and loss of hydrogen by diffusion. In fact, at ambient temperatures, pure zirconium metal (if not contaminated with an oxide film), will rapidly absorb hydrogen to form the hydride.

Metal hydrides can be grouped into three rather broad categories: 1) saline hydrides (e.g., alkaline earth hydrides such as LiH, NaH); 2) covalent hydrides (e.g., aluminum hydride, tin hydride); and 3) metallic hydrides. Of these hydrides, the metallic hydrides, which include zirconium hydride, are the most stable. Furthermore, zirconium hydride is one of the most stable metallic hydrides.

In the present context, the mechanisms that may affect the stability of zirconium hydride include:

- Reaction with water;

- Reaction with dissolved oxygen or air;
- Thermal dissociation, or thermally-driven redistribution of hydrogen and loss by diffusion; and
- Radiolytic dissociation.

The effects of these mechanisms are qualitatively discussed below.

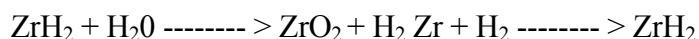
3.4.1 Reaction with Water

Monolithic zirconium hydride is stable in water up to approximately 100°C, and relatively stable up to 300°C. Under these conditions, the hydride reacts so slowly that even the powder is considered to be stable. At these temperatures, the rate of hydride reaction with water is negligible. Further, the extent of reaction with water is limited by the formation of a very thin, tenacious non-hygroscopic film of oxide that completely protects the bulk of the hydride from further hydrolysis.

The zirconium oxide films are characteristically relatively impermeable to hydrogen permeation. However, the thin ZrO₂ films formed at 25°C are denser and more impermeable than thicker ZrO films formed at elevated temperatures. The permeability of ZrO₂ films formed at 250°C is several orders of magnitude greater than the permeability of films formed at 25°C. The trend in permeation characteristics of these non-hygroscopic films is comparable for water permeation, except that the permeation constant for H₂O is many orders of magnitude lower than that of H₂ because of the molecular size difference.

Nevertheless, oxide films formed at a high temperature offer significant protection and stability for the zirconium hydride; the effect is particularly evident in harsher, very corrosive conditions. Zirconium hydride exposed to steam at 300 to 400°C will react very slowly over a period of days with only a slight weight gain due to formation of oxide film. However, at higher temperatures, particularly above 500°C, the resultant oxide film becomes more permeable to water. In addition, if there is a significant metal phase present, the zirconium oxide film can start to dissolve into the metal phase at temperatures higher than 500°C. Therefore, the oxide films on the hydride at high temperatures are not completely protective against further reaction. Nevertheless, at these temperatures the rate of reaction is still slow compared to the reactivity of other materials. Zirconium hydride quenched from beta phase (> 550°C) in water or brine shows minimal effects except for slight surface reaction.

In general, the lower the hydrogen content, the lower is the corrosion resistance of the zirconium hydride. However, when the hydride contains a considerable excess of zirconium metal, the metal may react with the hydrogen that is liberated by the hydrolysis to re-form some of the hydride mass:



In addition, alloys with uranium may have slightly lower corrosion resistance. While powders of Zr-U-H alloys (1:0.03: 1) may be quenched in water with formation of only light films of oxide, prolonged immersion in boiling water produces an oxide film that may flake

off, resulting in a slight mass loss (mass loss of 0.8 mg/cm² in one year).

3.4.2 Reaction with Oxygen or Air

Loss of hydrogen by oxidation of the zirconium hydride by the oxygen or air dissolved in basin water is not an issue in underwater storage. The zirconium oxide film on the hydride is an effective barrier to oxygen permeation as it is to hydrogen and water.

Metal hydrides, as a class, are considered strong reducing agents, and most will rapidly oxidize, many of them pyrophorically. Zirconium hydride, however, is one of the most stable of the metal hydrides. Monolithic zirconium hydride is stable in air up to 600°C. An exposure of monolithic zirconium hydride to 760°C in air for 100 hours oxidized the hydride only to a depth of 0.02 inches (500 microns). In addition, only negligible losses of hydrogen occur during exposures at temperatures up to 750°C in an oxidizing environment such as air or CO₂. Evidently, the initial oxide films that form in these reactions are highly effective barriers to oxygen and hydrogen permeation.

3.4.3 Thermal Dissociation

Loss of hydrogen by thermal dissociation of the hydride to its component elements is not an issue in wet fuel storage. The surface temperatures and the average fuel temperature are kept relatively low by water cooling in basin storage. As mentioned above, the protective zirconium oxide film is quite impermeable to hydrogen, and effectively prevents the desorption of free hydrogen and the decomposition of the hydride. A more germane question is - whether any hydrogen loss may have occurred at the higher temperatures of reactor service?

Almost all metal hydrides will dissociate to the metal and hydrogen at temperatures well below the hydride melting points. The decomposition temperature may be as low as ambient temperature for unstable hydrides, or as high as 1000°C for stable hydrides. The degree of dissociation will be a function of temperature, hydrogen pressure and the type of metal hydride. The extent of hydrogen loss by a hydride will depend on the extent of dissociation at a given temperature, the diffusion rate of hydrogen through the fuel matrix, and the diffusion rate through any barrier films or cladding.

Zirconium hydride has a moderately high thermal stability for hydride phases ranging from ZrH_{1.33} to ZrH₂. Zirconium hydride will dissociate slightly at elevated temperatures. However, the equilibrium hydrogen pressures from dissociation are low at 635°C, the equilibrium hydrogen pressure is 1 mm Hg; at 500°C, 0.1 mm Hg; and at 370°C, 0.001 mm Hg. These data suggest that hydrogen losses even at reactor temperatures will be relatively low, for the impervious oxide film will retain the free hydrogen. Performance measurements have indicated that the equilibrium hydrogen pressure at 760°C results in negligible hydrogen loss, and thus is insufficient to drive measurable diffusion of H₂ through the oxide film.

Partial dissociation of the hydride can result in hydrogen redistribution as a consequence of

an internal thermal gradient. Such gradients would be expected in reactor service and in storage. Such temperature gradients can establish a hydride concentration gradient, forming a hydrogen-rich phase at the cooler end of the gradient, and possibly cause a loss of hydrogen. In fact, disastrously large concentration gradients have been developed in metal hydride research for reactor applications. The dissociation-driven redistribution is a well-documented phenomenon in the metal hydrides, including zirconium hydride. However, in view of the documented impermeability of hydrogen in the zirconium oxide films, particularly for the low dissociation pressures characteristic for ZrH_2 , this mechanism would not be a realistic loss mechanism for stored fuels.

3.4.4 Radiolytic Dissociation

Dissociation of zirconium hydride can also occur by radiolysis due to the in-reactor neutron flux and the decay radiation. Since dissociation is a reversible process, and the recombination reaction is very fast, no irreversible, adverse effects are expected from radiolytic dissociation unless the hydrogen were to escape rapidly. Because of the permeation characteristics of the zirconium oxide film, hydrogen loss due to radiolytic dissociation is not realistic unless the zirconium hydride is radiolytically unstable and high pressures of hydrogen are produced.

Zirconium hydride is relatively stable in high radiation fields. No changes in characteristic dissociation pressures have been measured for irradiated zirconium hydride. Furthermore, no adverse effects have been detected in experimental irradiation studies on zirconium hydrides.

3.5 Radionuclide Inventory

Further information on the fuel is contained in references provided in Section J, Attachment J-L. There is a great variation in the burn-up for TRIGA fuel that is irradiated in different reactors and for differing uranium loading and U-235 enrichment. Table 3-2 presents a calculated radionuclide inventory for a high burn-up standard stainless steel clad TRIGA element as a function of decay time. The estimated dose rate with ten years of cooling at 3 meters in air is $1.2 \text{ E}+4$ mrem/hr. The estimated decay heat for a high burn-up TRIGA FLIP element with ten years of cooling is 2 watts.

3.6 References

Ebner, MA; "Stability of Zirconium Hydride Spent Fuels in Wet Storage", MAE-01-94, January 28, 1994.

Tomsio, N., *Characterization of TRIGA Fuel*, GA Technologies, GA-3442, October, 1986.

Table 3-2: Stainless Steel-clad TRIGA Fuel Activity (Curies) as a function of Decay Time.

BURNUP (BU)										
BU: U-235	7.0 g									
BU: % U-235	17.95%									
BU: MWd	6.65									
BU: MWd/MTU	34103									
U-235 DEPL	8.08 g									
ACTIVITY (CURIES)										
ISOTOPE	0-days*	14-days	28-days	0.25-years	0.5-years	1-years	3-years	5-years	10-years	20-years
H 3	9.781E-02	9.760E-02	9.738E-02	9.645E-02	9.511E-02	9.248E-02	8.266E-02	7.389E-02	5.582E-02	3.185E-02
BE 10	1.334E-07	1.334E-07	1.334E-07	1.334E-07	1.334E-07	1.334E-07	1.334E-07	1.334E-07	1.334E-07	1.334E-07
C 14	8.564E-04	8.564E-04	8.564E-04	8.564E-04	8.563E-04	8.563E-04	8.561E-04	8.559E-04	8.554E-04	8.543E-04
CL 36	1.870E-05	1.870E-05	1.870E-05	1.870E-05	1.870E-05	1.870E-05	1.870E-05	1.870E-05	1.870E-05	1.870E-05
CR 51	4.603E+01	3.243E+01	2.285E+01	4.695E-00	4.789E-01	4.984E-03	5.843E-11	6.851E-19	1.020E-38	0.000E+01
MN 54	2.769E-00	2.684E-00	2.602E-00	2.262E-00	1.847E-00	1.232E-00	2.441E-01	4.834E-02	8.439E-04	2.572E-07
FE 55	1.944E+01	1.924E+01	1.905E+01	1.819E+01	1.702E+01	1.489E+01	8.742E-00	5.131E-00	1.354E-00	9.433E-02
FE 59	8.559E-01	6.899E-01	5.560E-01	2.099E-01	5.147E-02	3.095E-03	4.049E-08	5.296E-13	3.277E-25	0.000E+01
CO 60	1.647E+01	1.639E+01	1.631E+01	1.594E+01	1.542E+01	1.444E+01	1.110E+01	8.538E-00	4.425E-00	1.189E-00
NI 59	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.612E-03	3.611E-03
NI 63	4.444E-01	4.443E-01	4.442E-01	4.436E-01	4.428E-01	4.411E-01	4.345E-01	4.280E-01	4.122E-01	3.823E-01
ZN 65	3.469E-01	3.334E-01	3.204E-01	2.677E-01	2.065E-01	1.229E-01	1.544E-02	1.938E-03	1.083E-05	3.381E-10
SE 79	8.657E-05	8.657E-05	8.657E-05	8.657E-05	8.657E-05	8.657E-05	8.657E-05	8.657E-05	8.656E-05	8.655E-05
KR 85	2.320E-00	2.314E-00	2.309E-00	2.283E-00	2.246E-00	2.175E-00	1.911E-00	1.680E-00	1.216E-00	6.372E-01
RB 87	5.921E-09	5.922E-09	5.922E-09	5.922E-09	5.922E-09	5.922E-09	5.922E-09	5.922E-09	5.922E-09	5.922E-09
SR 89	1.748E+02	1.443E+02	1.190E+02	4.997E+01	1.428E+01	1.166E-00	5.189E-05	2.308E-09	3.048E-20	0.000E+01
SR 90	1.951E+01	1.949E+01	1.948E+01	1.940E+01	1.928E+01	1.905E+01	1.817E+01	1.732E+01	1.538E+01	1.212E+01

Y 90	2.041E+01	1.952E+01	1.948E+01	1.940E+01	1.929E+01	1.906E+01	1.817E+01	1.733E+01	1.538E+01	1.213E+01
Y 91	2.142E+02	1.827E+02	1.548E+02	7.317E+01	2.483E+01	2.857E-00	5.010E-04	8.787E-08	3.580E-17	5.942E-36
ZR 93	5.291E-04	5.294E-04	5.294E-04	5.294E-04	5.294E-04	5.294E-04	5.294E-04	5.294E-04	5.294E-04	5.294E-04
ZR 95	2.573E+02	2.211E+02	1.899E+02	9.574E+01	3.562E+01	4.933E-00	1.813E-03	6.666E-07	1.727E-15	1.159E-32
NB 93M	4.798E-05	4.886E-05	4.975E-05	5.372E-05	5.941E-05	7.056E-05	1.124E-04	1.503E-04	2.296E-04	3.386E-04
NB 94	5.405E-05	5.405E-05	5.405E-05	5.405E-05	5.405E-05	5.405E-05	5.404E-05	5.404E-05	5.403E-05	5.401E-05
NB 95	2.634E+02	2.573E+02	2.445E+02	1.617E+02	7.065E+01	1.072E+01	4.026E-03	1.480E-06	3.834E-15	2.574E-32
NB 95M	1.808E-00	1.633E-00	1.408E-00	7.103E-01	2.643E-01	3.659E-02	1.346E-05	4.946E-09	1.281E-17	8.601E-35
MO 93	6.225E-05	6.225E-05	6.225E-05	6.225E-05	6.225E-05	6.224E-05	6.221E-05	6.219E-05	6.213E-05	6.201E-05
TC 99	2.934E-03	2.942E-03	2.942E-03	2.942E-03	2.942E-03	2.942E-03	2.942E-03	2.942E-03	2.942E-03	2.942E-03
RU103	1.235E+02	9.647E+01	7.536E+01	2.468E+01	4.934E-00	1.971E-01	5.017E-07	1.277E-12	1.321E-26	0.000E+01
RU106	1.894E+01	1.844E+01	1.796E+01	1.595E+01	1.343E+01	9.525E-00	2.410E-00	6.097E-01	1.963E-02	2.035E-05
RH103M	1.112E+02	8.697E+01	6.793E+01	2.225E+01	4.448E-00	1.777E-01	4.523E-07	1.152E-12	1.191E-26	0.000E+01
RH106	1.936E+01	1.844E+01	1.796E+01	1.595E+01	1.343E+01	9.525E-00	2.410E-00	6.097E-01	1.963E-02	2.035E-05
PD107	4.165E-06	4.165E-06	4.165E-06	4.165E-06	4.165E-06	4.165E-06	4.165E-06	4.165E-06	4.165E-06	4.165E-06
AG110	3.406E-01	1.639E-04	1.576E-04	1.323E-04	1.027E-04	6.191E-05	8.171E-06	1.079E-06	6.829E-09	2.737E-13
AG110M	1.281E-02	1.232E-02	1.185E-02	9.946E-03	7.721E-03	4.654E-03	6.144E-04	8.110E-05	5.134E-07	2.057E-11
AG111	1.437E-00	3.917E-01	1.065E-01	2.962E-04	6.091E-08	2.574E-15	0.000E+01	0.000E+01	0.000E+01	0.000E+01
CD113M	2.724E-03	2.720E-03	2.715E-03	2.693E-03	2.661E-03	2.598E-03	2.363E-03	2.149E-03	1.695E-03	1.054E-03
CD113	0.000E+01	0.000E+01	0.000E+01	0.000E+01	0.000E+01	0.000E+01	0.000E+01	0.000E+01	0.000E+01	0.000E+01
CD115M	6.316E-02	5.081E-02	4.088E-02	1.530E-02	3.703E-03	2.171E-04	2.564E-09	3.028E-14	1.451E-26	0.000E+01
IN114	3.824E-03	1.249E-03	1.027E-03	4.235E-04	1.181E-04	9.175E-06	3.345E-10	1.220E-14	9.789E-26	0.000E+01
IN114M	1.588E-03	1.305E-03	1.073E-03	4.426E-04	1.234E-04	9.587E-06	3.496E-10	1.274E-14	1.023E-25	0.000E+01
IN115M	6.362E-01	8.926E-03	1.174E-04	1.074E-06	2.600E-07	1.524E-08	1.800E-13	2.126E-18	1.019E-30	0.000E+01
SN119M	2.839E-00	2.730E-00	2.624E-00	2.194E-00	1.694E-00	1.012E-00	1.283E-01	1.626E-02	9.310E-05	3.052E-09
SN121M	4.134E-04	4.132E-04	4.130E-04	4.120E-04	4.106E-04	4.077E-04	3.966E-04	3.857E-04	3.599E-04	3.133E-04
SN123	3.663E-01	3.398E-01	3.152E-01	2.244E-01	1.376E-01	5.166E-02	1.028E-03	2.044E-05	1.141E-09	3.555E-18
SN125	1.553E-00	5.677E-01	2.074E-01	2.197E-03	3.107E-06	6.214E-12	0.000E+01	0.000E+01	0.000E+01	0.000E+01
SN126	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.090E-05
SB124	5.053E-02	4.300E-02	3.660E-02	1.767E-02	6.180E-03	7.555E-04	1.689E-07	3.777E-11	2.823E-20	1.577E-38
SB125	2.000E-00	1.991E-00	1.976E-00	1.893E-00	1.779E-00	1.570E-00	9.518E-01	5.772E-01	1.653E-01	1.356E-02

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SB126	4.483E-02	2.050E-02	9.377E-03	2.839E-04	1.298E-05	1.133E-05	1.133E-05	1.133E-05	1.133E-05	1.133E-05
SB126M	2.268E-02	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.091E-05	8.090E-05
TE123M	1.303E-04	1.202E-04	1.108E-04	7.683E-05	4.529E-05	1.573E-05	2.295E-07	3.346E-09	8.588E-14	5.659E-23
TE125M	4.428E-01	4.453E-01	4.470E-01	4.452E-01	4.283E-01	3.824E-01	2.323E-01	1.409E-01	4.033E-02	3.309E-03
TE127	6.488E-00	1.347E-00	8.103E-01	5.148E-01	2.882E-01	9.029E-02	8.703E-04	8.388E-06	7.651E-11	6.364E-21
TE127M	9.053E-01	8.562E-01	7.856E-01	5.256E-01	2.942E-01	9.218E-02	8.885E-04	8.564E-06	7.811E-11	6.498E-21
TE129	2.638E+01	1.945E-00	1.457E-00	3.951E-01	6.015E-02	1.394E-03	4.016E-10	1.157E-16	5.160E-33	0.000E+01
TE129M	3.969E-00	2.988E-00	2.238E-00	6.070E-01	9.240E-02	2.141E-03	6.170E-10	1.778E-16	7.927E-33	0.000E+01
I129	4.876E-06	4.883E-06	4.887E-06	4.897E-06	4.900E-06	4.900E-06	4.900E-06	4.900E-06	4.900E-06	4.900E-06
I131	1.083E+02	3.328E+01	9.955E-00	4.266E-02	1.636E-05	2.405E-12	0.000E+01	0.000E+01	0.000E+01	0.000E+01
XE131M	1.202E-00	9.005E-01	5.086E-01	1.756E-02	9.076E-05	2.199E-09	7.463E-28	2.532E-46	0.000E+01	0.000E+01
XE133	2.502E+02	4.836E+01	7.620E-00	1.787E-03	1.036E-08	3.481E-19	0.000E+01	0.000E+01	0.000E+01	0.000E+01
CS134	3.229E-00	3.188E-00	3.147E-00	2.970E-00	2.731E-00	2.308E-00	1.179E-00	6.021E-01	1.123E-01	3.903E-03
CS135	2.140E-04	2.141E-04	2.141E-04	2.141E-04	2.141E-04	2.141E-04	2.141E-04	2.141E-04	2.141E-04	2.141E-04
CS136	1.462E-00	6.972E-01	3.324E-01	1.171E-02	9.373E-05	6.008E-09	1.014E-25	1.712E-42	0.000E+01	0.000E+01
CS137	2.057E+01	2.056E+01	2.054E+01	2.046E+01	2.034E+01	2.010E+01	1.920E+01	1.833E+01	1.633E+01	1.296E+01
BA136M	2.413E-01	1.149E-01	5.478E-02	1.929E-03	1.545E-05	9.901E-10	1.671E-26	2.822E-43	0.000E+01	0.000E+01
BA137M	1.947E+01	1.945E+01	1.943E+01	1.935E+01	1.924E+01	1.902E+01	1.816E+01	1.734E+01	1.545E+01	1.226E+01
BA140	2.292E+02	1.073E+02	5.025E+01	1.631E-00	1.160E-02	5.874E-07	3.860E-24	2.536E-41	0.000E+01	0.000E+01
LA140	2.303E+02	1.234E+02	5.782E+01	1.877E-00	1.335E-02	6.760E-07	4.442E-24	2.918E-41	0.000E+01	0.000E+01
CE141	2.178E+02	1.625E+02	1.206E+02	3.131E+01	4.474E-00	9.140E-02	1.591E-08	2.771E-15	3.504E-32	0.000E+01
CE142	7.084E-09	7.084E-09	7.084E-09	7.084E-09	7.084E-09	7.084E-09	7.084E-09	7.084E-09	7.084E-09	7.084E-09
CE144	1.976E+02	1.910E+02	1.846E+02	1.582E+02	1.267E+02	8.116E+01	1.369E+01	2.308E-00	2.695E-02	3.675E-06
PR143	2.170E+02	1.182E+02	5.779E+01	2.281E-00	2.154E-02	1.919E-06	1.211E-22	7.636E-39	0.000E+01	0.000E+01
PR144	1.978E+02	1.910E+02	1.846E+02	1.582E+02	1.267E+02	8.117E+01	1.369E+01	2.308E-00	2.695E-02	3.675E-06
PR144M	2.373E-00	2.292E-00	2.215E-00	1.899E-00	1.520E-00	9.740E-01	1.642E-01	2.770E-02	3.234E-04	4.410E-08
ND144	2.137E-13	2.162E-13	2.185E-13	2.283E-13	2.400E-13	2.569E-13	2.819E-13	2.861E-13	2.870E-13	2.870E-13
ND147	8.428E+01	3.508E+01	1.459E+01	2.770E-01	9.097E-04	9.811E-09	1.327E-28	1.796E-48	0.000E+01	0.000E+01
PM145	6.449E-06	6.534E-06	6.617E-06	6.958E-06	7.365E-06	7.941E-06	8.530E-06	8.156E-06	6.776E-06	4.583E-06
PM147	5.137E+01	5.142E+01	5.114E+01	4.901E+01	4.588E+01	4.021E+01	2.371E+01	1.398E+01	3.735E-00	2.665E-01
PM148M	1.761E-00	1.392E-00	1.100E-00	3.806E-01	8.228E-02	3.846E-03	1.835E-08	8.755E-14	4.354E-27	0.000E+01

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PM148	7.820E-00	1.346E-00	2.700E-01	2.151E-02	4.635E-03	2.166E-04	1.034E-09	4.931E-15	2.453E-28	0.000E+01
SM145	6.441E-05	6.260E-05	6.083E-05	5.348E-05	4.440E-05	3.061E-05	6.912E-06	1.561E-06	3.782E-08	2.221E-11
SM147	8.599E-10	8.726E-10	8.854E-10	9.416E-10	1.018E-09	1.158E-09	1.562E-09	1.800E-09	2.052E-09	2.137E-09
SM151	1.570E-01	1.576E-01	1.575E-01	1.573E-01	1.570E-01	1.564E-01	1.541E-01	1.517E-01	1.460E-01	1.352E-01
EU152	1.260E-02	1.258E-02	1.254E-02	1.244E-02	1.228E-02	1.197E-02	1.081E-02	9.765E-03	7.570E-03	4.549E-03
EU154	1.528E-01	1.523E-01	1.519E-01	1.497E-01	1.468E-01	1.410E-01	1.200E-01	1.022E-01	6.829E-02	3.052E-02
EU155	3.916E-01	3.895E-01	3.875E-01	3.782E-01	3.652E-01	3.406E-01	2.575E-01	1.948E-01	9.689E-02	2.397E-02
EU156	1.808E-00	9.645E-01	5.091E-01	2.837E-02	4.405E-04	1.062E-07	3.586E-22	1.211E-36	0.000E+01	0.000E+01
GD153	6.373E-03	6.121E-03	5.881E-03	4.907E-03	3.778E-03	2.241E-03	2.769E-04	3.422E-05	1.837E-07	5.299E-12
TB160	1.751E-02	1.531E-02	1.339E-02	7.301E-03	3.044E-03	5.292E-04	4.834E-07	4.416E-10	1.114E-17	7.082E-33
TL206	9.810E-06	1.436E-12	1.436E-12	1.436E-12	1.436E-12	1.436E-12	1.436E-12	1.436E-12	1.436E-12	1.436E-12
TL207	6.975E-10	6.982E-10	7.015E-10	7.443E-10	8.300E-10	1.030E-09	1.875E-09	2.817E-09	5.662E-09	1.312E-08
TL208	4.073E-08	4.137E-08	4.242E-08	4.768E-08	5.391E-08	6.476E-08	9.258E-08	1.056E-07	1.127E-07	1.051E-07
PB210	6.616E-15	6.783E-15	6.896E-15	7.137E-15	7.332E-15	7.778E-15	1.099E-14	1.703E-14	4.912E-14	2.229E-13
PB211	6.995E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
PB212	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
BI211	6.996E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
BI212	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
PO212	7.263E-08	7.378E-08	7.564E-08	8.502E-08	9.613E-08	1.155E-07	1.651E-07	1.882E-07	2.009E-07	1.875E-07
PO215	6.995E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
PO216	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
RN219	6.995E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
RN220	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
FR223	9.641E-12	9.822E-12	1.001E-11	1.084E-11	1.207E-11	1.461E-11	2.592E-11	3.893E-11	7.828E-11	1.814E-10
RA223	6.995E-10	7.002E-10	7.035E-10	7.464E-10	8.323E-10	1.033E-09	1.880E-09	2.825E-09	5.678E-09	1.315E-08
RA224	1.134E-07	1.151E-07	1.181E-07	1.327E-07	1.500E-07	1.802E-07	2.577E-07	2.938E-07	3.135E-07	2.926E-07
RA226	2.441E-14	2.497E-14	2.554E-14	2.818E-14	3.215E-14	4.074E-14	8.375E-14	1.411E-13	3.510E-13	1.087E-12
RA228	5.693E-10	5.737E-10	5.781E-10	5.977E-10	6.253E-10	6.785E-10	8.658E-10	1.018E-09	1.286E-09	1.541E-09
AC227	6.986E-10	7.118E-10	7.250E-10	7.854E-10	8.745E-10	1.059E-09	1.878E-09	2.821E-09	5.673E-09	1.314E-08
TH227	6.900E-10	6.925E-10	6.992E-10	7.500E-10	8.363E-10	1.017E-09	1.854E-09	2.786E-09	5.600E-09	1.297E-08
TH228	1.132E-07	1.162E-07	1.192E-07	1.321E-07	1.494E-07	1.796E-07	2.572E-07	2.931E-07	3.133E-07	2.925E-07

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TH229	1.466E-10	1.495E-10	1.524E-10	1.655E-10	1.846E-10	2.229E-10	3.760E-10	5.291E-10	9.117E-10	1.677E-09
TH230	3.384E-11	3.414E-11	3.443E-11	3.578E-11	3.774E-11	4.168E-11	5.791E-11	7.485E-11	1.203E-10	2.238E-10
TH231	1.407E-04	6.688E-05	6.687E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05
TH232	1.681E-09	1.681E-09	1.681E-09	1.681E-09	1.681E-09	1.681E-09	1.681E-09	1.681E-09	1.681E-09	1.681E-09
TH234	5.263E-05	5.248E-05	5.239E-05	5.223E-05	5.220E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05
PA231	1.146E-08	1.153E-08	1.159E-08	1.184E-08	1.220E-08	1.291E-08	1.575E-08	1.858E-08	2.565E-08	3.978E-08
PA233	5.538E-02	3.869E-02	2.701E-02	5.333E-03	5.199E-04	1.297E-05	8.244E-06	8.248E-06	8.264E-06	8.315E-06
PA234M	8.792E-05	5.249E-05	5.239E-05	5.223E-05	5.220E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05
PA234	7.562E-05	6.823E-08	6.811E-08	6.789E-08	6.785E-08	6.785E-08	6.785E-08	6.785E-08	6.785E-08	6.785E-08
U232	3.306E-07	3.314E-07	3.314E-07	3.313E-07	3.312E-07	3.308E-07	3.281E-07	3.241E-07	3.113E-07	2.836E-07
U233	7.854E-07	7.932E-07	7.986E-07	8.087E-07	8.110E-07	8.112E-07	8.113E-07	8.114E-07	8.115E-07	8.119E-07
U234	8.616E-07	8.624E-07	8.631E-07	8.666E-07	8.716E-07	8.817E-07	9.220E-07	9.617E-07	1.058E-06	1.241E-06
U235	6.686E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05	6.686E-05
U236	8.440E-05	8.440E-05	8.440E-05	8.440E-05	8.440E-05	8.440E-05	8.440E-05	8.440E-05	8.441E-05	8.441E-05
U237	1.284E+01	3.050E-00	7.245E-01	1.095E-03	2.998E-07	2.016E-07	1.831E-07	1.663E-07	1.308E-07	8.083E-08
U238	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05	5.219E-05
NP237	8.130E-06	8.214E-06	8.234E-06	8.241E-06	8.241E-06	8.241E-06	8.244E-06	8.248E-06	8.264E-06	8.315E-06
PU236	3.025E-07	3.007E-07	2.979E-07	2.856E-07	2.688E-07	2.381E-07	1.464E-07	9.008E-08	2.673E-08	2.356E-09
PU237	1.070E-06	8.646E-07	6.989E-07	2.672E-07	6.675E-08	4.166E-09	6.318E-14	9.582E-19	8.583E-31	0.000E+01
PU238	6.941E-03	6.994E-03	7.003E-03	7.035E-03	7.064E-03	7.085E-03	7.013E-03	6.905E-03	6.638E-03	6.135E-03
PU239	3.665E-02	3.678E-02	3.678E-02	3.678E-02	3.678E-02	3.678E-02	3.677E-02	3.677E-02	3.677E-02	3.676E-02
PU240	1.416E-02	1.416E-02	1.416E-02	1.416E-02	1.416E-02	1.416E-02	1.415E-02	1.415E-02	1.414E-02	1.413E-02
PU241	8.624E-01	8.608E-01	8.592E-01	8.521E-01	8.419E-01	8.219E-01	7.465E-01	6.780E-01	5.331E-01	3.295E-01
PU242	1.538E-06	1.538E-06	1.538E-06	1.538E-06	1.538E-06	1.538E-06	1.538E-06	1.538E-06	1.538E-06	1.538E-06
PU244	2.551E-15	2.551E-15	2.551E-15	2.551E-15	2.551E-15	2.551E-15	2.551E-15	2.551E-15	2.551E-15	2.551E-15
AM241	1.332E-03	1.385E-03	1.438E-03	1.675E-03	2.013E-03	2.678E-03	5.177E-03	7.438E-03	1.219E-02	1.872E-02
AM242M	9.613E-06	9.611E-06	9.609E-06	9.602E-06	9.591E-06	9.569E-06	9.482E-06	9.396E-06	9.185E-06	8.775E-06
AM242	7.841E-02	9.601E-06	9.561E-06	9.554E-06	9.543E-06	9.521E-06	9.435E-06	9.349E-06	9.139E-06	8.732E-06
AM243	9.820E-07	9.830E-07	9.830E-07	9.829E-07	9.829E-07	9.829E-07	9.827E-07	9.825E-07	9.820E-07	9.811E-07
CM242	3.838E-02	3.642E-02	3.431E-02	2.623E-02	1.781E-02	8.206E-03	3.769E-04	2.437E-05	7.568E-06	7.221E-06
CM243	1.348E-06	1.346E-06	1.345E-06	1.340E-06	1.331E-06	1.315E-06	1.253E-06	1.193E-06	1.057E-06	8.289E-07

CM244	1.364E-05	1.364E-05	1.362E-05	1.353E-05	1.340E-05	1.314E-05	1.218E-05	1.128E-05	9.315E-06	6.355E-06
CM245	1.102E-10	1.102E-10	1.102E-10	1.102E-10	1.102E-10	1.101E-10	1.101E-10	1.101E-10	1.101E-10	1.100E-10
CM246	3.145E-12	3.145E-12	3.145E-12	3.145E-12	3.144E-12	3.144E-12	3.143E-12	3.142E-12	3.140E-12	3.135E-12
CM247	6.602E-19	6.602E-19	6.602E-19	6.602E-19	6.602E-19	6.602E-19	6.602E-19	6.602E-19	6.602E-19	6.602E-19
Subtotal Ci**	3.219E+03	2.272E+03	1.793E+03	9.998E+02	6.124E+02	3.604E+02	1.562E+02	1.086E+02	7.508E+01	5.270E+01
Total Ci***	2.311E+04	2.325E+03	1.807E+03	1.007E+03	6.163E+02	3.617E+02	1.562E+02	1.086E+02	7.509E+01	5.271E+01
* Decay time following fuel element exposure.										
** Subtotal Ci (Curies): Total Activity of the 145 isotopes listed here in the table.										
*** Total Ci (Curies): Total Activity of the ORIGEN output isotopes.										

The following reference documents are added to the end of Section J, Attachment J-L.

- | | |
|------|---|
| 1-21 | Engineering Design File 2873, Revision 2, Peach Bottom Core Shipping Configuration for Transfer from CPP-749 to Spent Nuclear Fuel Dry Storage Project (Reference Drawing No. 518304) |
| 1-22 | INEEL Drawing No. 518304, Revision 4, Peach Bottom Core 1 Fuel Transfer from CPP-749 |
| 1-23 | Engineering Design File 2874, Revision 2, Peach Bottom Core 2 Shipping Configuration for Transfer from CPP-603IFSF to Spent Nuclear Fuel Dry Storage Project (Reference Drawing No. 518306) |
| 1-24 | INEEL Drawing No. 518306, Revision 2, Peach Bottom Core 2 Fuel Transfer from IFSF in CPP-603 |
| 1-25 | Engineering Design File 2875, Revision 1, Shippingport LWBR Spent Nuclear Fuel Data for Transfer from CPP-749 to Spent Nuclear Fuel Dry Storage Project (Reference Drawing No. 518305) |
| 1-26 | INEEL Drawing No. 518305, Revision 2, Shippingport Light Water Breeder Reactor Fuel Transfer from CPP-749 |
| 1-27 | Engineering Design File 2876, Revision 1, TRIGA Spent Nuclear Fuel Data for Transfer from IFSF to the Spent Nuclear Fuel Dry Storage Project (Reference Drawing No. 518307) |
| 1-28 | INEEL Drawing No. 518307, Revision 2, Selected TRIGA Fuel Transfer from IFSF in CPP-603 |
| 1-29 | Engineering Design File 3084, Revision 2, Source Term Data for Shippingport LWBR, Peach Bottom, TRIGA, and Fermi Blanket SNF for Peach Bottom Cask SAR Revision |

- 1-30 INEEL Drawing No. 522272, Revision 0, CPP-603 IFSF Gap Plug for CAN-GSF-276 Canister with Three BU-GSF-BEL Buckets PLUG-GSF-76-XX Assembly (2 sheets)
- 1-31 INEEL Drawing No. 516777, Revision 0, CPP-603 IFSF 5 Position Standard TRIGA Fuel Can Assembly and Details CAN-GSF-134-XX (2 sheets)
- 1-32 INEEL Drawing 508724 Rev 3, Foreign Research Reactor (FRR) Storage Canister, CAN-GSF-BEL-XX
- 1-33 INEEL Drawing 453318 Revisions 3, 4 and 5, IFSF Lighter Weight Storage Canister, CAN-GSF-276-XX
- 1-34 TRIGA Heidelberg II, Appendix A - Spent Nuclear Fuel Transfer Data Form(s), dated February 16, 2001
- 1-35 INEEL Drawings 519574, 519575, and 519576, all Revision 0, Cask Liner/Overpack for Peach Bottom Casks CA-SF-005 and CA-SF-006